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THE TRANSMISSION OF POWER BY ELECTRICITY.

BY FRANK J. SPRAGUE.

[*A Lecture delivered before the* FRANKLIN INSTITUTE, *November 12, 1888.*]

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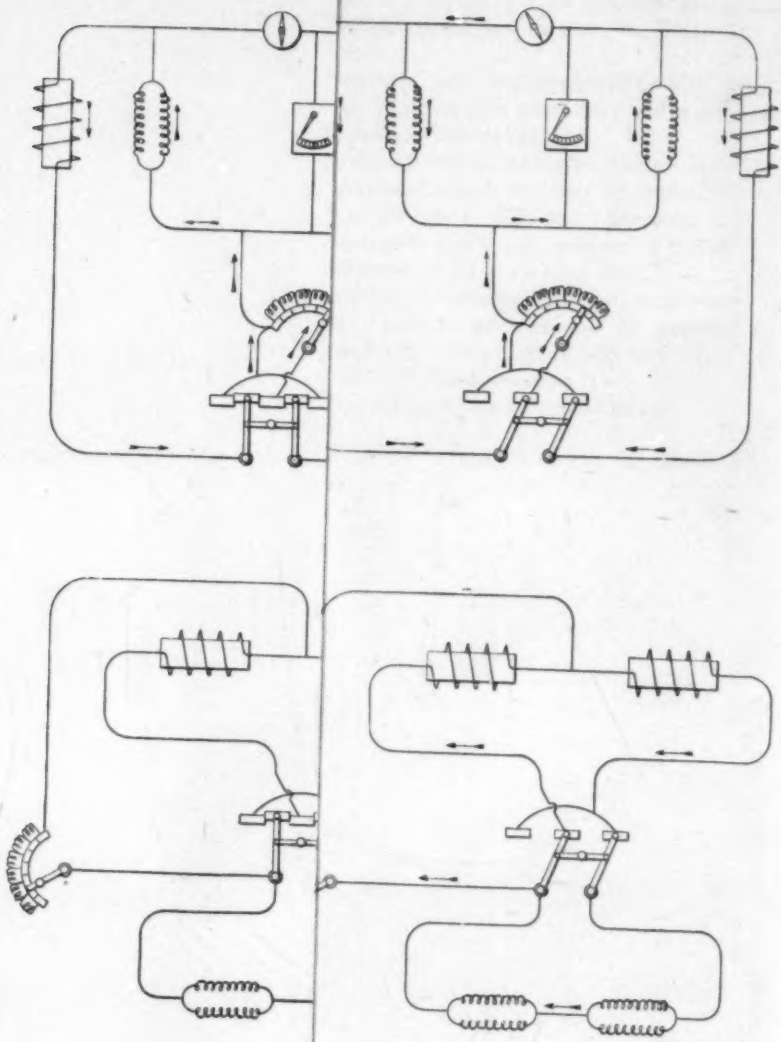
MR. SPRAGUE: MEMBERS OF THE INSTITUTE, LADIES AND GENTLEMEN:

The transmission of power by electricity is now an established fact, and every day, for the ordinary uses of life, its application is rapidly spreading. The principles of its application are well settled. The dynamo and motor have been brought to a remarkably high efficiency and leave little to be desired as converters of energy. The future of the transmission of power from central stations, under ordinary conditions, is a matter of commercial development. The special application of the transmission of energy over



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long distances depends chiefly upon the demand which exists for such transmission and the intelligent application of principles already well known. Distance is a relative term. It does not seem a difficult matter to transmit five horse-power ten miles, but a gigantic problem to transmit 1,000 horse-power one mile; the latter appeals to our imagination, and yet the former is, in one sense, the more difficult problem, not so much because of any difference in the general principles involved, as in the fact that in the construction of machines of high electro-motive force we meet with more serious difficulties in the matter of insulation and the element of personal danger to the operator.

It is not my intention to enter into any general discussion of the question, nor to go into the particulars of dynamo and motor construction, for the limits of this paper would not permit this; but I shall briefly point out the different phases which the transmission of power by electricity may assume, show some of the general conditions which must be met, emphasize the practicability of such transmission, and then more particularly discuss a new method for the determination of the elements of a single transmission which my own practice has brought out, and which I have found it advisable to adopt. I shall here consider only the use of a continuous current and a direct transmission.

For the purpose of this paper, we may consider the following cases of transmission:

(1) Transmission from a central station conveniently situated near the centre of a manufacturing district, over an area of from one to 100 square miles, in units varying from a fraction of a horse-power to fifty or 100 horse-power. Such a system is illustrated by the Edison two and three wire circuits in operation in a large number of cities in the United States. Referring to my own work alone, its practicability is illustrated by the fact that in Boston I have nearly 150 motors in operation, in New York about 125, and in New Orleans nearly 100; there being in various stations not less than 1,200 machines, varying from a half to thirty horse-power, and used in no less than 130 different

industries. These machines are operated under potentials, varying from 100 to 440 volts, and are run on constant potential circuits. The maximum distance in this class of work is, at present, about one mile on 220 volt circuit, and the practical limit for this potential from a single station is about four square miles.

In considering how far this Central Station work can be carried, we must bear in mind certain facts; power transmitted means the transference of an energy whose value may be expressed, as in all cases of fluid transmission, by the product of the quantity and pressure—that is, by the product of the electro-motive force and the current. With any given amount of energy transmitted, the electro-motive force and the current will vary inversely. The laws of distribution are clear. With any given work done, loss on the line, electro-motive force at the terminals of the motor, and distribution, the weight of the copper will vary as the square of the distance, its cross section, of course, varying directly as the distance. With the same conditions, the weight will vary inversely as the square of the electro-motive force used at the motor. With the same cross section of conductor, the distance over which a given amount of power can be transmitted will vary as the square of the electro-motive force. If the weight of copper is fixed, with any given amount of power transmitted and given loss in distribution, the distance over which the power can be transmitted will vary directly as the electro-motive force. Hence, if it is practical to economically transmit power one mile under 200 volts pressure—that is, if the investment in copper is not disproportionate—then, by increasing our pressure to 800 volts, we can transmit this power four miles without changing the ratio of the investment. Of course, I am now speaking of the use of a bare wire and assuming that the cost of stringing the four miles of given weight of wire is no more than stringing an equal weight one mile. Of course this is not strictly so. As a matter of fact, however, it is a practical thing to transmit and deliver over an area of 100 square miles, from one central station, under a pressure not exceeding 1,000 volts; and

the larger the amount of power distributed and the greater the number of units, the more cheaply it can be done. The question arises, "Would it be economical, in a district of this character, to deal with the larger horse-powers?" My answer is unquestionably "yes." It is true that the actual efficiency of double conversion would vary from fifty to seventy per cent., depending upon the distance and the pressure used, but experience has developed the fact that not over about thirty-five to forty per cent. of the maximum capacity of all the machines in a circuit represents the average duty demanded; and since this is so, it follows that the amount of power that can be contracted for will at least equal, probably considerably exceed, the steam-power in the central station. I say "steam-power" because in a large majority of cases in this kind of transmission steam and not water will be the prime source of energy. When we consider the economy of operating a large, well-designed and properly constructed steam plant, and the great advantage to the user where the electric motor replaces the ordinary steam engine, it does not need a very shrewd commercial sense to see the advantages of this method. In fact, there is not a city in the United States, no matter how numerous its factories, which could not have them run better than to-day by a well-constructed electrical plant, working under pressures which would not be dangerous to life.

(2) Somewhat analagous to the system we have just discussed is the transmission at constant potential with the motors applied with various loads at constantly varying points. Such a system of transmission is that which exists in the parallel circuit system for railroad work. There are now in the United States alone no less than sixty or seventy electric railways in operation or under construction. The most extensive of these, up to the present writing, is the Richmond Union Passenger Railway, whose characteristics may be cited as an illustration. This has about twelve miles of track and is operated under a pressure of about 450 volts. The central station has a capacity of about 375 horse-power. The farthest point reached is about three and one-

half miles from the station. The equipment consists of forty-one cars, with eighty-two machines whose aggregate normal capacity is between 600 and 700 horse-power, nearly double the steam capacity. The car units develop anywhere from nothing to twenty horse-power. The maximum load which has been put upon the system at one point at any time is the starting of about twenty-two cars about two miles from the station, requiring, probably about 125 to 150 horse-power. This road now having made nearly 600,000 miles, the practicability of this kind of transmission may be accepted as an assured fact.

(3) The transmission from one station to another, at which latter point are a number of independent machines, each of which has a variable load and is required to run at constant speed. An example of this is the transmission from a water-power to a stamp-mill, where the different batteries of stamps are operated by independent machines. The most satisfactory method is to maintain at the receiving station a constant potential, and to use for the receiving machines motors wound to be self-regulating, according to laws which I gave some time since. The dynamos should either be compound wound or the field regulators adapted to increase the electro-motive force of the machine as the load increases. Constancy of prime speed is an essential; or, if it does not exist, then there must be a combined mechanical and electrical governor which will assure a definite electro-motive force, which shall correspond to each variation of the current.

(4) The transmission between two stations as last mentioned, save that the condition of automatic regulation is not essential. In this case the dynamos may be either shunt, compound or series wound, and the motors either shunt, cumulative or series. Such a plant is now running in one of the mines at Aspen, Col. The electro-motive force there used is about 450 volts and the distance somewhere about a mile.

(5) Transmission with a single line over a long distance, with the motors distributed throughout the entire line. This is a case which may occur in some manufacturing dis-

tricts, but is more apt to occur in such work as canal building, dredging or mining in river beds. It can be accomplished by the use of a constant current circuit, using constant current motors, or with the same aggregate electro-motive force on a constant potential circuit. A marked case is the mining operations carried on at the Big Bend Tunnel of California, in a large river cañon, where about a dozen machines, developing from five to ten horse-power, are used for operating pumps and derricks, and are supplied by two lines of from 600 to 1,000 volts potential over a distance of about eight miles from the central station.

Thus far I have considered the distribution with a practically constant potential at the motors, and the parallel method of distribution, as distinguished from the constant current method, where the motors are in series. This last for large powers and many machines, is a limited and unnatural method, the former a comprehensive and natural method, which facts are entirely independent of the question of relative electrical potentials or currents, because, on constant potential circuits, we can work at 100, 1,000 or 5,000 volts if we choose.

Among some of the special cases of power transmission I will briefly note the following:

(6) The transmission from one point to another, using two series wound machines, where the motor has a constant torque or a load per turn. The motor being at rest, as the electro-motive force of the generator is raised by increasing its speed, or by increasing the resistance of a shunt around its field with any given speed, the current, which may be expressed by

$$\frac{E}{K}$$

will increase until the torque is great enough to start the motor against its load, when the current will become stationary. A motor electro-motive force being now created, the current is expressed by

$$\frac{E' - e}{K} = \frac{E}{K}$$

Any increase of the electro-motive force of the generator

will be followed by an equal increment in the motor electro-motive force, the difference between the two, and hence the current, remaining perfectly constant. The speed of the motor being known for one electro-motive force and load, its speed for any other electro-motive force may be determined, and fast or slow hoisting be regulated entirely at the generating station.

(7) The transmission to one point from another, with a single generator and a single motor with variable loads, presents two solutions. The first is the use of the compound dynamo and differential motor; but a far more interesting solution is the use of two series machines which, when properly proportioned, become perfectly self-regulating. I will briefly touch upon the theory of this method of transmission. We have the condition that the same current passes through each field and armature, and also the condition that the speed is constant, while the work is variable. Since work may be expressed as a product of speed and torque, and since the speed is constant, it follows that the motor torque must vary directly as the work. Again, we have as an expression for the work done the product $e\,C$. Since the speed of the motor is constant, e must vary directly as the strength of the field, which, where the magnetization is low, will vary directly as the current, and when more highly magnetized in a much less degree. E being $E\,.\,m\,.\,f$ of the generator and K the resistance of the circuit, we have—

$$C = \frac{E - e}{K}$$

and, as we have already stated,

$$E \text{ varies as } e, \text{ as } E - e, \text{ as } C$$

and work—

$$\text{varies as } e\,C, \text{ as } C^2, \text{ as } e^2, \text{ as } E^2$$

The dynamo likewise being driven at a constant speed, E likewise varies as the strength of its field. If m equals the number of turns of wire in the dynamo field, and n those in the motor field, then the ampère turns or magnetizing forces are expressed by $m\,C$ and $n\,C$. It follows from what

proceeds that the magnetizations due to $m\,C$ and $n\,C$ should vary in the same proportion; in other words, the characteristics of the generator and the motor must be similar between the limits of the variation in load. Should the machines used be improperly proportioned, then the regulation can be largely determined by putting a resistance in the line circuit, or shunting one or other of the fields with a resistance. The electrical efficiency of the circuit being

$$\frac{e}{E'}$$

we have the following fact: That the electrical efficiency is a constant for all loads with the limit of automatic regulation. If the machines are of the same general type, then, when correctly proportioned, the ratio of their weights and watt capacities should be the same as the electrical efficiencies of the circuit.

(8) As a modification of the proceeding, especially where large powers, long distances and necessarily high potentials are used, it is advisable to divide the generators and motors into a battery of machines of indentically the same weight and character, the number of the machines being the ratio of the electrical efficiencies, the generators all to be driven from the same line of shafting, and the motors to drive on to a common line, and the current to pass through all the machines in series. This I consider the only sound method when dealing with large powers and high potentials and single units of generation and recovery, especially where automatic regulation is required. Its advantages are manifest. One of the greatest difficulties which we have in dynamo-electric construction in closed-circuit machines, especially where using the drum system of winding, is the difficulty of securing perfect insulation when high potentials are used.

One thousand or 1,200 volts seem as high as it is now advisable to go in machines of this type, where currents of any magnitude are to be used. In the transmission of electricity reliability is an essential, and a potential of 3,000 or 4,000 volts, distributed over three or four machines in series,

is, despite the increased number of machines, far less liable to cause failure than where put into one machine of the aggregate size of the four; and in the event of the breaking down of one machine, the units may be so proportioned that by a corresponding change in the units at the other station, or a proper variation of the regulating shunt to the fields, it becomes quite possible to continue automatic operation. As an illustration of this distribution of machines, if wishing to use dynamos and motors of an electrical efficiency of about ninety-five per cent, a commercial efficiency each of about ninety per cent., and with about sixty per cent. as the total commercial efficiency of the circuit, I would, with a distance of about nine miles, use five series machines identical in construction, each wound for about 1,200 volts, three of which machines would be driven by a common line of shafting at the generating station, and two driving on to a common line of shafting at the receiving station. It will be noticed that both in the single and multiple unit series system, the electro-motive force and the current vary equally. I hope at an early date to be able to show this last system in practical operation.

The indirect methods of transmission, such as through a secondary battery of generators, motor generators, and secondary batteries, I will not here discuss.

I come now to the consideration of some new, interesting and very practical formulæ for determining the elements of a single transmission of a given amount of power. Before entering upon its discussion, it is necessary to state why I differ somewhat from the methods which have hitherto been published.

Those who have followed with any particular interest the progress of the development of the transmission of power by electricity, must be more or less familiar with the early experiments of Deprez and the papers by Prof. Lodge and Mr. Gisbert Kapp. The experiments of Deprez have not had that practical result which had been hoped for them, and it seems to me as if an attempt had been made to go further than commercial demands warrant. We must avoid the consideration of the subject from a purely

theoretical light. *No system of transmitted energy can be made profitable unless the cost of the same at the far end, including not only the actual cost of production but the capitalized value of the possibility of accident due to the fact that the prime source of energy is not under immediate control, shall be less for the transmitted energy than the price that would have to be paid for its production there by water, steam, or some other agency.* As attractive as the use of water-power appears as a prime source of energy, its uses are very limited, and every year will become more and more so; and unquestionably the great future of the transmission of power by electricity will depend upon the fact that in a large proportion of cases it will be cheaper to carry energy in the shape of electricity on a wire by the shortest cut between two points than to pack it up in the shape of wood or coal on the back of a mule or behind a horse. I have no sympathy with the theoretically possible, but really impracticable consideration of the transmission of power, from Niagara to New York; for Niagara has a far greater value as a sublime spectacle than as a commercial factor in metropolitan affairs. I will then in my estimates confine myself to that which is practical and possible, and will consider the conditions under which power shall be so transmitted. Messrs. Lodge and Kapp have deduced some very interesting formulæ, but one of the conditions which was taken into account by them was that of leakage. In a purely theoretical study this is as it should be; but the transmission of power by electricity to meet the demands of actual life must above all things be reliable; and by this I mean, not merely certain to supply power at the end of the line, but to deliver a definite percentage under perfect regulation and a known cost. This cannot be done with the uncertain and variable element of an unknown but material leakage; for if this leakage exists, then it must be a variable quantity depending not only upon the condition of weather but likewise upon the continual variation which exists in the electro-motive force when the load is not constant. We meet then with the condition that in the successful installation of a plant for the transmission of power, we must be

free from material leakage; that is, the leakage must be so small under all possible conditions of service as to never interfere with the efficiency and reliability of the transmission. Hence in the formula which I in practice adopt to determine the elements of my work, I shall assume a line of practically perfect insulation. I am justified in this because the additional expense to secure this desirable result is more than compensated for by the reliability of the service. We can only accomplish this by the most careful line erection and choice of insulators. It can be materially aided by running the positive and negative leads each on an independent line of poles and perfectly clear of all trees, and of course a well-covered wire can be used. When a double line of poles is used, it is advisable to wrap the lower ends with bare wire for a distance of about six feet above the ground, and to connect these bases together; or, if the poles are close together, a galvanized iron or copper wire should be taken around each pole at the distance given and joined together. This is to avoid the possibility of a serious shock in wet weather, which might be received by a person leaning against a wet pole if any accident should occur to the line insulators when very high potentials are used.

In the formulæ which are given, I shall make use of the term "couple efficiency." As long ago as the spring of 1888 Drs. John and Edward Hopkinson made tests of efficiency of double conversion with the Edison-Hopkinson and Manchester dynamos, the efficiency of the former rising at times to over eighty-seven per cent., and of the latter to nearly seventy-eight per cent. No others have made so thorough an analysis of the action of dynamo-electric machinery, and my own experience warrants me in assuming, for the purpose of this paper, a commercial efficiency of double conversion, where two machines are connected by a metallic circuit of no appreciable resistance, or what I have called the "couple efficiency," of not less than eighty per cent., which is only allowing about ninety per cent. commercial efficiency for the dynamos and motors. It will oftentimes rise higher than this, but I think it advisable in a specific formula to

adopt a perfectly safe figure. This couple efficiency for either single, shunt, or series machines, or nests of machines, is easily determined with considerable accuracy and small expenditure of power. The method I prefer was one independently proposed but similar to that first put into practice by Dr. John Hopkinson, that English scientific investigator to whom we all owe so much. It may be termed the variable differential method; and depends upon the use of an electro-mechanical couple. The first diagram illustrates the testing of two shunt-wound machines. Two such machines are belted to a common line of counter-shafting having three pulleys, each being given its proper speed. To the third pulley is connected a motor of about one-third the capacity of one of the machines to be tested, this motor being one of a perfectly well-known commercial efficiency, and provided with means for varying its speed; or, if desired, the power can be transmitted through a good dynamometer. The like terminals of the large motors are then connected together, an ampère meter put into this circuit, and a potential galvanometer connected across the terminals. One terminal of each field is likewise connected to its proper line, and the other terminals of these fields are brought to the movable levers of a two-way circuit changing switch. One contact is carried to the main line, and between it and the other two is inserted a variable resistance, which in the middle position of the switch is short circuited. We have, then, the two large motors connected in an electro-mechanical couple, and to the same shafting is connected a third motor. The main dynamo being started, the switch set in the middle position, the motor is speeded up, which sets the counter-shafting in operation and drives both the machines as dynamos, each exciting its own field. If the machines are symmetrical, no current whatsoever will pass over the branch connecting the two; they are simply in the position of two dynamos in parallel circuit with each other, with no external circuit and no path over which the current can flow except that through their field magnets; consequently, very little power, save that of friction, is taken. The switch being

moved in one direction, the resistance is thrown into the field of one machine. The electro-motive force which it develops at this particular speed is now reduced; it becomes a motor, and current will flow over the connecting mains from the other machine, which is still a dynamo, which current is roughly expressed by the quotient of the difference of the electro-motive forces of the two machines, divided by the resistance of the circuit. By varying the resistance in the fields this current can be made of any value up to the limit. We have here, then, one machine acting as a motor, and driving on to the counter-shafting with a certain number of horse-power, this counter-shafting driving the other machine as a dynamo with a certain greater amount of horse-power, this second machine furnishing the current which operates the first as a motor. The deficit, or loss of efficiency between the two machines and the friction is supplied by the third. By reversing the switch the resistance is first cut out of one field, and then thrown into the field of the other machine. This machine now becomes a motor, and the other machine becomes a dynamo. This reversal is not instantaneous, because it takes time for the field magnets to charge and discharge. The ampère metre will drop to zero, and will then rise again progressively.

This method of testing can be used for two purposes, one for testing the actual horse-power developed and the couple efficiency, which can be done by measuring the current, the electro-motive force between the machines and the horse-power delivered to the shafting by the third motor, and for the other purpose of testing simply the heating capacity of the armature coils with a given number of ampères. For this latter purpose it does not matter practically whether the machines are run at their normal speed and generate their normal electro-motive force, or whether some lower electro-motive force is used. If a lower electro-motive force is present, it simply means that there must be a greater ratio of difference between the field magnet strengths and a larger resistance used with the reversing switch.

When desiring to test the two series machines, the con-

nections are somewhat different, and are illustrated in the second diagram; the machines, of course, being mechanically connected as in the first instance. We can similarly test a multiple unit series system; and in all these cases, by the introduction of an artificial resistance into line, we can produce all the phenomena of an actual long-distance transmission. This method of testing, where there can be an immediate variable and controllable reversibility of the dynamo and motor, and test of the efficiency of transmission under widely varying conditions, illustrates in one of the most beautiful ways the flexibility and utility of electric transmission.

Assuming then, that we have no leakage, and that our dynamos and motors have a definite known efficiency, we will take up the consideration of a few formulæ.

Let l = distance between the generating and receiving stations in feet, plus the sag.

n = number of effective horse-power to be delivered on the motor shaft.

E = electro-motive force at the terminals of the motor.

v = number of volts fall of potential on the line.

$E + v$, or E', being, of course, the electro-motive force at the beginning of the line or the terminals of the generator.

a = efficiency of the motor.

CM = circular mils of conductor.

An electrical horse-power is 746 watts, watts being the product of current by electro-motive force. Then for any horse-power n, a motor efficiency of a and an e. m. f. of E at the motor terminals, we have the number of ampères equal to—

$$\frac{746\ n}{E\ a} \qquad (1)$$

Allowing m ohms as the resistance per mil-foot of copper, the total line resistance would be

$$\frac{2\ m\ l}{CM}$$

for a complete metallic circuit. From the above we have for

the drop or fall of potential on the line,

$$v = \frac{746\ n}{E\ a} \times \frac{2\ m\ l}{C\ M} = \frac{1492\ n\ m\ l}{E\ a\ C\ M}$$

or

$$C\ M = \frac{1492\ n\ m\ l}{E\ v\ a}. \qquad (2)$$

Substituting for m its approximate value, 10·5,

$$C\ M = \frac{15666\ n\ l}{E\ v\ a}$$

Let me give a practical illustration. Suppose we have a motor, the efficiency of which is ninety per cent at 400 volts electro-motive force and when developing ten horse-power, and that we wish to transmit this ten horse-power 5,000 feet from a station and elect to lose about nine per cent on the line.

Our initial electro-motive force will be 440 volts, and we would have,

$$C\ M = \frac{15666 \times 10 \times 5000}{400 \times 40 \times \cdot 90} = 54396$$

which is about equal to a No. 4 B. W. G.

Again, suppose we wish to transmit five horse-power over a distance of one mile on a complete metallic circuit of 45,000 cm., allowing five per cent. increase of length for sag, and no leakage. Suppose further, that the initial line potential be 300 volts, and that we wish to have 250 volts at the motor terminals, it is required to find the commercial efficiency which the motor must have.

Transposing our formula we have,

$$a = \frac{15666\ n\ l}{E\ v\ C\ M}$$

and substituting,

$$a = \frac{15666 \times 5 \times 5544}{250 \times 50 \times 45000} = 76\ \%$$

This formula is useful in determining what we cannot as well as what we can do. For example, if we made the

condition ten horse-power, all others remaining the same, the commercial efficiency of the motor would have come out 152 per cent., a most excellent machine indeed, and yet it is precisely this absurd thing that people practically say they will do in many of the statements which are made in relation to this subject. No science admits of more easy determination of conditions by plain and simple laws, and none brooks less violation of them.

(*To be continued.*)

SOME AMERICAN CONTRIBUTIONS TO METEOROLOGY.

By Prof. Wm. M. Davis, of Harvard College.

[*A Lecture delivered before the* Franklin Institute, *November 19, 1888.*]

(*Concluded from Vol. cxxvii, page 115.*)

As Espy's synopsis represents the more mature form of his theories, it is taken as the source of most of the following quotations, rather than the earlier papers, in which many of his statements are exaggerated. His *Fourth Meteorological Report* (1857), also contains much of value, and furnishes entertaining as well as instructive reading.

In the first place, he attempted to establish by experiment how great a degree of cooling there would be in consequence of the expansion of an ascending mass of air, and concluded that it would be about one degree and a quarter for every hundred yards of ascent; later determinations show that it is somewhat too small, the value now accepted being about one-fifth greater. This rate of cooling will prevail till the dew-point is reached.

The formula still often given to ascertain the height at which the dew-point is gained, or at which the base of cumulus clouds will stand, on the assumption that they are formed in uprising currents or air from the earth's surface,

is: height = complement of dew-point × 300 feet. I must plead guilty to having aided in giving currency to this error, but my regret thereat has been lessened by seeing that Professor Ferrel has made the same statement in his *Recent Advances.* The mistake would have been advoided if Espy's advice had been followed about weighing the contents of his synopsis carefully; for he there clearly explained that the dew-point of the ascending column will not be reached when the air has cooled down to the dew-point that it had at the ground; "for the vapor itself grows thinner, and the dew-point falls about one-quarter of a degree for every hundred yards of ascent."

He goes on to say: "As soon as cloud begins to form, the caloric of elasticity of the vapor or steam is given out into the air in contact with the little particles of water formed by the condensation of the vapor. This will prevent the air in its further progress upward, from cooling so fast as it did up to the point." When the dew-point is 70°, the rate of cooling after condensation begins is reduced to five-eighths of a degree for an ascent of 300 feet; if the dew-point is higher, the cooling is a little less; if lower, a little more. "It follows that when the cloud is of great perpendicular height above its base, its top must be much warmer than the atmosphere at that height, and consequently much lighter." When hail or snow is formed, the caloric of fluidity given out will still further retard the cooling.

Espy is perfectly right, when judged by the subsequent progress of meteorology, in claiming much for this theory; its value may be seen from its continual use in modern essays and text-books; it may be added that very few of the modern text-books present the case more clearly than Espy did in his synopsis, except that his old-fashioned terminology is, of course, exchanged for one more consonant with the mechanical theory of heat.

The course of regular diurnal phenomena dependent on changes of temperature is given in masterly form by Espy. "Clouds will more frequently begin to form in the morning, increase in number as the heat increases, and cease altogether in the evening, when the surface of the earth becomes

cold by radiation. The commencement of the up-moving columns in the morning will be attended with an increase of winds, and its force will increase with the increasing columns, both keeping pace with the increasing temperature. This increase of wind is produced partly by the rush of air on all sides at the surface of the earth toward the centre of the ascending columns, producing fitful breezes; and partly by the depression of the air all around the ascending columns, bringing down with it the motion which it has above, which is known to be greater than that which the air has in contact with the asperities of the earth's surface." This is the original explanation of the diurnal increase in the velocity of the wind, which has since been rediscovered independently by Köppen.

An essential corollary of the theory, fully understood by Espy, was that descending currents would be warmed by compression, at the same rate as ascending currents are cooled by expansion; hence, as the Committee of the French Academy—Arago, Pouillet and Babinet—reported on Espy's theories in 1841: "We should not hereafter adduce in the mean state of the atmosphere a descending current as a cause of cold," for, however cold the air may be aloft, it will be heated by compression in descent, so that on reaching the ground it would have high and not low temperature. The origin of thunder-storms by the descent of cold air from above into warm air below is objected to and with good reason, for in such case, the storm cloud would be hollow, forming only where the descending current might cause condensation in the air that it entered. The mass of the descending current itself could not by any possibility become cloudy. But ascending currents must be cloudy after a moderate ascent, unless very dry when rising from the ground; and as ascent continues, the cloud becomes heavier and may yield rain. Thus did Espy's theory furnish a simple and effective process to explain the general conditions of atmospheric condensation; yet, even to the present time, the process suggested in the last century by Hutton is quoted, if not accepted, by most text-books, though it can be shown on good physical grounds to be altogether

insignificant in its effects. Hutton thought that if two masses of air, both saturated but of unlike temperatures, were mixed, condensation would result, because the temperature of the mixture would be below its dew point. This is perfectly true. But the process fails to explain the facts, chiefly because it does not occur. It is a rare thing to find adjacent masses of air of unlike temperatures and both saturated. It is almost impossible for them to mix in the intimate way required by Hutton, except to a very small extent. And even if they should mix in large volume, the amount of rain produced would not be as much as that which falls, on any admissible assumption as to the masses of air concerned. Although so defective, Hutton's theory is still quoted extensively, and Espy's simple theory that clouds and rain result from the mechanical cooling of ascending currents of air, is relatively neglected. Where clouds and rain occur, there the air ascends; and its ascent is due to its instability.

Espy thus explained the rainy belt around the equator, not by saying as is still so common and so incorrect that the moist, warm and light surface air rises into the cool air above, thereby implying that the lower air is cooled by the cold of the upper air; but because the warm, light air cools as it rises and so condenses its vapor spontaneously. In the same way, winds that are constrained to rise as they flow over mountain ranges, become cloudy and give forth rain, not because they are cooled by the cold of the high mountain, but because they are cooled as a consequence of the work that they do in expanding during ascent. They would be rainy even if the mountain were warm. Conversely, cloudy currents descending from mountain passes become clear, not because they enter the warm lower air, but because they are warmed by compression in descent. A consequence of the passage of moist winds over mountains is seen to be not only the excess of rain on the windward slope, but also the occurrence of warm, dry winds at the foot of the leeward slope; and thus a rational explanation was early given for the winds of the Foehn or Chinook kind. (See "A History of the Foehn in *Mountain Meteorology*" by W. M. D., Appalachia, iv, 1886, 344).

Perhaps the most striking illustration of Espy's deductive method is seen in the explanation that he gave to the clear space in the centre of tropical storms, known as the "eye of the storm." Clouds being the product of ascending currents clear air must indicate the pressure of descending currents; hence, in the centre of the general ascending and cloudy winds of the storm there must be a descending and hence clear current. This curious suggestion is in Espy's *Fourth Meteorogical Report*, where my attention was called to it by Mr. H. H. Clayton: as in the case of diurnal increase of wind velocity, Espy's explanation of the clear eye of the storm has been repeated independently by Köppen a few years ago. Espy even advocated the artificial production of rain in time of drought by making large fires to excite vertical convectional currents, and his works include some extraordinary examples of showers thus produced. A certain correspondent wrote him that one summer day he ascended Monadnock, a fine isolated mountain in southwestern New Hampshire. The sky was cloudless; away on the low ground, a farmer had set fire to his waste brush, and the smoke rose high in a straight column; at last a cloud formed over it, the cloud grew, and soon gave forth a shower of rain, moving away from its point of beginning as it entered the upper wind. Not another cloud appeared. Other curious examples of artificial rain are given, and some of them are so remarkable that we must wonder at the little consideration they now receive.

But Espy, like Redfield, found in storms the chief problem of meteorology. Dove, then the leading meteorologist of Europe, supplied with numerous tabular records of temperature, rainfall, and other climatic elements from the old observatories of the continent, became chiefly a statistical meteorologist. Redfield and Espy, in a new country where old records were rare, devoted their attention to actual processes, not to numerical averages. Redfield approached the problem, as we have seen, purely from the inductive, observational side, without many preconceptions; Espy approached it with his mind pretty well made up as to the processes involved and with strong preconceptions in

favor of the theory by which the processes were explained. Redfield found that storm winds whirl around in essentially circular paths about a centre of low pressure, and he attributed the low pressure to the centrifugal force of the whirl. Espy said that storms are essentially examples of convectional circulation, that the central low pressure must be their cause and not their effect; and that the winds must flow radially inward to the place where the pressure is lowest, causing clouds and rain by ascent there. Each one supported his views by numerous examples, and as the truth lay really between them, each one was right to a certain extent. Redfield drew most of his examples from storms at sea, recorded in the logs of vessels, and it is not a little curious that the fuller material now in our possession shows conclusively that it is precisely in marine storms that the winds are most nearly circular, as Redfield maintained. Espy took his examples, when he got so far as to appeal to the facts, from land storms almost exclusively, and the more radial course now known to characterize the land winds gave some color to his theory of radial indraft. He utilized, first with the assistance of this INSTITUTE, and afterwards under Government aid, the records from many volunteer observers, and gathered a large number of observations of high value. His conclusions were that storms sweep across our country from west to east; that they possess a medial axis of low pressure, generally extending north and south, with the central minimum on the middle of the axis; and that the winds flow toward the axis from either side, with a tendency toward the centre. The much fuller and more accurate records of our Signal Service, show that in a general way this is true, for our storms have prevailingly an elongated area of low pressure; but the winds undoubtedly circulate spirally around the centre, and do not flow radially toward it.

Our two great students differed, I may say quarrelled, on this point. Each one was persuaded that he was right; but to their differences of opinion I do not care to give emphasis. It is more profitable to study the points on

which they were right than to magnify their errors and differences. Yet in this matter of the circulation of the winds in storms, one cannot help dwelling on their disagreement, and all the more because it would have been avoided if they had taken heed of an extraordinary little article "On the Rotary Action of Storms," that appeared in the *American Journal of Science* in 1843, at the height of their discussion. Charles Tracy, then a young graduate of Yale College, who had a taste for mathematics, said to himself, if we may reconstruct his mental revery, these eminent men are both in a sense right. Espy is right in maintaining that the tendency of the wind in storms is centripetal, because the primary cause of the movement is the low pressure at the centre of the storm; and Redfield is right in insisting that winds have an essential whirling movement, because the rotation of the earth will inevitably cause such a whirl in any system of centripetal winds. In this simple explanation, the true value of the deflective effect of the earth's rotation was for the first time applied in meteorology. The effect of the earth's rotation on the cause of the winds was first suggested by Hadley in 1735; but this explanation, although still commonly current, is wrong in implying that the earth's rotation affects only the meridional component of a body's motion, and that it alters the velocity of motion. Tracy, unconsciously following certain mathematicians, stated the problem correctly, and was the first to apply it in its true value to the winds. It matters not in what direction a body moves, it is deflected to the right of its course in this hemisphere, and to the left in the other; the force of the deflection increasing with the sine of the latitude.

Tracy recognized that if an original impulse were the cause of the rotary movement of a storm, "the forces of the whirlwind would be rapidly exhausted, and its existence must speedily cease. A stable source of momentum, adapted to originate and sustain the rotary movement, is still required; and it is now proposed to develop such a source of momentum in the forces generated by the earth's diurnal rotation." It is admitted that Espy had established "a

qualified central tendency of the air, in both the general storms and the smaller tornadoes," and then, acting on this beginning, the deflective force arising from the earth's rotation is called on "to cause and maintain a whirlwind." * * "Upon the same principle the tornado, the typhoon and the wide-spread storm of the Atlantic, if their currents move toward a central spot, must have a rotary character. * * In every such case, the incoming air must be regarded as a succession of rings taken off the surrounding atmosphere and moving slowly at first but swifter as they proceed toward the centre. Each such ring is affected by the law of deviation during its passage. * * * and hence the ring begins to revolve when far from the centre, turns more and more as it draws near it, and finally as it gathers about the central spot all its forces are resolved into a simple whirl. * * * In the southern hemisphere, the same law of deflection produces contrary results." It is clearly shown that the deflective force is independent of the direction of motion, but varies with the sine of the latitude. "The necessary condition, centripetal motion, may arise whenever a central spot subjected to intense heat is surrounded by a cool atmosphere. * * * The destructive storms of our sea-coast may have such an origin among the eastern islands of the West Indies, from which they appear to proceed."

There are few scientific essays that outrank this one for clearness and originality of statement. As already said, it contains the first application of the correctly defined deflective force to meteorological questions, and clearly anticipates some of Ferrel's original and independent work of several years later date. Although it was followed by no other study in our science, I think Tracy's name deserves fully as eminent mention among American meteorologists as is accorded to Hadley among the English. Early in 1883, I had the pleasure of meeting Mr. Tracy, just after having as it were resurrected his early paper of forty years before. He said he had often wondered why attention had not been given to it, quietly adding, "I have never been able to see that it was incorrect." It is to be regretted that so original a mind was diverted entirely from a study in which we must think it would have labored to great advantage.

Our next American, Ferrel, is certainly the greatest meteorologist native to America, if not the greatest of the world, if we judge of his rank by the advance that he has given to the science. To no other man do we owe so much in the way of large, broad and as is now generally conceded correct views of atmospheric phenomena. As Espy had deductively applied physical principles to meteorological problems, so Ferrel applied mathematical methods to their solution, and greatly to their benefit, not only in the results immediately secured, but in the indication that he gave of a new line of inquiry open to the meteorologist of the future. His contributions from first to last cover the whole field of mathematical and physical meteorology, electricity excepted.

Ferrel's explanation of the general planetary circulation of the winds is one of his greatest discoveries. It has certainly advanced farther toward the truth than any other theory ever suggested. It may be indicated by the following considerations.

The first general view of atmospheric circulation over the earth as a whole, calls for convectional interchange of air currents between equator and poles. An overflow of warm expanded light air takes place from the equatorial belt, and a return current of cold heavy air comes back from the poles. Under this simple view, there would be only north and south winds, and we should find low pressure around the equator where the overflow takes place, and high pressure about the poles, whence the under return current comes. But the winds blow obliquely, and the polar regions are characterized by low pressure, not by high pressure. Herein lies one of the great meteorological puzzles that remained unsolved until Ferrel approached it. Theory seems to be wrong, but in truth, as Ferrel showed, it is not wrong but only incomplete. The text-books give no sufficient, explanation of the facts. Buchan, the leading meteorologist of Great Britain, had but a lame explanation of it to offer: he attributed the south polar low pressure to the "presence of an excessive amount of moisture in the atmosphere." The belts of high pressure around the tropics are also insufficiently explained by most writers: they are

regarded as the effect of the crowding of the equilateral overflow as it advances along the converging meridians toward the poles; but if this were true, surely the highest pressure should be at the poles, where the meridians converge fastest.

Ferrel's explanation is vastly better. He shows that as the winds run toward the poles, they are deflected by the earth's rotation into oblique courses, and hence a great polar whirl results, turning in the same direction as the cyclonic storms, and reversing the high pressure that would be caused by differences of temperature alone into a low pressure, by the action of centrifugal force. The air thus held away from the poles is seen accumulated in the tropical belts of high pressure. (The share that Alex. Thompson, of Edinburgh, had in this discovery is referred to in *Science*, 1887.) The case is so simple that it seems like an exaggeration to proclaim it as a great discovery; but great discoveries have a way of seeming very simple after they are made.

I have spoken of this at length, because it has a direct bearing on the theory of storms. Mention has already been made of Dove's disagreement with Redfield as to the whirling character of our ordinary bad weather storms: Dove believed that the alternation of our southerly wet winds and northerly cold and dry winds was not the effect of the passage of rotary storms as Redfield had explained it, but simply the interplay of the equatorial and polar currents of the general planetary circulation: he thought that the return polar current was northerly or northwesterly in this hemisphere, about opposite the southwesterly equatorial current. This is mechanically impossible, as Ferrel has shown, and his explanation of storms as the conflict of planetary winds falls to the ground when it is seen that our return polar current is a northwesterly wind, gradually running obliquely out of the polar whirl below, while the equatorial overflow current as gradually enters it above. The polar current cannot be of itself a northeast wind until it reaches the trade wind belt; but if some cause arise, locally more powerful than the planetary gradients,

the latter may be as locally overcome, and a new wind will be the result; it is this new local wind that Dove had identified with the polar component of the general circulation, but which we must regard, in the light of Ferrel's results, as a distinct interruption in it. I give importance to this difference because Dove's view has been largely accepted, and has its followers to this day.

The comparison that Ferrel instituted between the general, permanent circulation of the atmosphere over a hemisphere of the earth and the local, temporary circulation in a cyclone is one of the broadest views that has yet been presented to the meteorological student. A cyclone is an area of warm or moist and hence light air, which therefore becomes locally the centre of a vertical convectional circulation. The rotation of the earth requires that the vertical circulation shall be compounded with a rotary circulation; and the centripetal forces thus produced cause a further decrease of pressure at the centre. The spiral inflow below is accelerated by gravity, and gains energy as it advances; but the spiral outflow above has to run against the gradients, and thus expends the energy gained below. In the polar whirls, the central air is cold and heavy, and the high pressure that would be thus produced is reversed to a low pressure by the whirling; here the convectional circulation is downward at the centre, the spiral inflow aloft is accelerated, and the spiral outflow below has to run against the gradients; it is a cyclone with a cold centre. In both, the air withheld from the centre is seen in a surrounding ring of high pressure.

An important application of this is found in the study of anti-cyclones. These are generally treated as if they were independent meteorological individuals, like cyclones, but with the circulation reversed; descending instead of ascending at the centre; but Ferrel's demonstration shows that if such were the case, the distinguishing mark of anti-cyclones, their central high pressure, would be reversed to low pressure, as it is at the cold poles of the planetary whirls; the areas of high pressure that are so common on our weather maps are therefore regarded as in part the effect

of the continental distribution of pressure, and in greater part as the effect of the overlapping of the high pressure rings of two or more adjacent cyclones.

Ferrel's theory of tornado action is as original as those already given. It has no rival: unlike all others, it accounts not only for the quality of the tornado whirl, but for the quantity of its blast as well; it gives a rational explanation of the marvellous concentration of energy in the tornado centre. It is impossible to do justice to it in a brief abstract; the reader should consult the original essays in which, if the mathematical treatment is difficult to follow, the explanatory chapters are at least open to any diligent student. Indeed, if the meteorologists of the country were more familiar with Ferrel's writings it would be greatly to our advantage, for although so well grounded, his theories have received little general recognition. This is probably in part because his essays—especially their mathematical portions—require close reading; but it is in greater part the result of inconspicuous publication, and the habit of teachers and readers in general to stop at text-books and compilations instead of going to original papers. Ferrel's first essay appeared in the *Nashville Journal of Medicine and Surgery* in 1856, and his second was in *Runkle's Mathematical Monthly* (Cambridge, Mass.) a few years later. Neither of these journals gave any popular currency to Ferrel's ideas. In 1861 and in later years, several articles were published in the same *American Journal of Science*, in which most of Redfield's contributions had come out, and all of these have been republished in the professional papers of the Signal Service; so that now there is less excuse than formerly for neglect of these fundamental contributions. In 1878 and subsequently, the more elaborate *Meteorological Essays* were published by the Coast Survey "for the use of the Coast Pilot;" a neat little sarcasm, the pilot must have thought, for in most part they are intelligible only to the mathematically-elect; but the pages that compare theory with fact are fine reading and deserve to be much better known than they are. Finally the *Recent Advances of Meteorology* was published as an appendix to the Chief Signal Officer's reports for 1886; and

at present it is gratifying to learn that Professor Ferrel is preparing a popular book in which his theories will be presented in form for the general student.

The laborious analysis of wind records from all parts of the world made by Coffin serve admirably as tests of Ferrel's theories. An essay on "The Winds of the Northern Hemisphere" appeared in the sixth volume of the *Smithsonian Contributions* in 1852, and over twenty years later the twentieth volume of the same publication contained the final tables and charts for the world, which are the most extensive yet published. These were completed after Coffin's death by his son, and are accompanied by a general discussion from the competent hand of the Russian meteorologist, Woeikoff. Although the nature of most of the records made it impossible to discuss the velocity of the wind, and therefore its direction only was considered, still even though thus incomplete, these charts are yet the best source of information for a great part of the world. The general circulation of the wind thus determined gives satisfactory confirmation of Ferrel's theories; but as only surface winds are considered, the field is by no means yet exhausted; observations of upper clouds and on high mountains in various parts of the globe are still greatly desired. All this deserves much more extended mention than can be given it here; I have time only for the following reference to storms, which but seldom come under Coffin's special attention. He wrote in 1853, that the irregular motions of the wind are best accounted for "by supposing that in the general current of the atmosphere, there are occasional eddies ('cyclones'), in which the air revolves spirally from right to left in the northern hemisphere, and from left to right in the southern, the curve making an angle with radius vector equal to that which the mean direction of the wind makes with the maximum and minimum line of the barometer, and that the barometer falls in the forward half of these eddies and rises in the latter half, the amount of rise and fall diminishing as we recede from the central axis on either side * * * Now,

it is remarkable that this is the very manner in which the best observations show it [the air] to move in the region of storms, during which it is known that our greatest barometric changes are apt to occur; and our discussion seems to prove that the two great American champions of the law of storms, with those who have followed the one or the other of them on the other side of the water, are both right. The attention of one being chiefly directed to the evidence of rotary motion, he failed to make prominent the inward tendency, though I am aware he has even admitted the probability of its existence, while the other, laboring to establish the latter motion, omitted the former" (*Amer. Assoc. Proc.*, 1853, 89, 91). This is an inductive confirmation of the deduction that Tracy had given ten years before.

The veteran American meteorologist of our time remains to be mentioned. Professor Loomis of Yale College has for fifty years been one of our leaders, and to his text-book of meteorology most of us who have any knowledge of the science turn as our first introduction to it. His first articles followed Redfield's first by but few years, and in 1843, when he was studying out with great labor the scattered records of a land storm, it appears that he was not satisfied with either Redfield's circles or Espy's radii, for in all storms he saw "certain common characteristics, namely, an inward motion with a tendency to circulate against the sun."* It is significant to find the centripetal motion mentioned here before the circular. This same paper closes with a most interesting suggestion concerning the results that would be gained from a year's series of two daily meteorological charts of the United States. We must all congratulate the venerable author on having not only lived to see the accomplishment of this early desire, but on working successfully in his advanced age on our weather charts, and producing from them the finest inductive statement concerning the physical peculiarities of cyclonic storms that has yet been published. Just as Coffin's work affords inductive

* *Trans. Amer. Phil. Soc.*, ix, 1846, 181.

foundation for Ferrel's theories of the planetary circulation, so Loomis's results give safe ground for Ferrel's theoretical views of cyclonic circulation. These investigators have followed very different paths, and in the agreement of their conclusions we find the best confirmation of the correctness of the modern physical views of our science.

From the numerous precise statistical statements that Loomis has presented, I quote a few that will illustrate not only the value but the character of his purely inductive method: indeed, for the beginner, there are few examples of inductive research better adapted to place the method before him. The average velocity and course of many storms is taken from the weather maps of the Signal Service; it is twenty-six miles an hour, and directed to N. 81° E. The rain area generally extends eastward about 550 miles. Now divide all the storms into two classes: (1) All the slow storms, whose velocity is less than the average; (2) all the fast storms, whose velocity is greater than the average. Then measure the forward distance of the rain area for all the individuals of the slow class, and take its average; do the same for all the fast storms. It then appears clearly that the rain area extends far ahead of the fast moving storms, and but little ahead of the slow ones; and on the theory of concomitant variations, we must conclude that velocity and rain area are in some way connected, either as common results of some other cause, or as cause and effect. It has been thought that the forward extension of the rain area, itself the effect of some cause yet to be detected with definiteness, is the cause in good part of the fast motion of the storm: but exception has been taken to this view. In the same way, analyze the directions of the storms; the average direction of all that turn more north than the normal average is N. 44° E.; the average direction of the longer axis of the rain area of the same storms is N. 53° E.; the more southerly storms run S. 69° E., and their rain areas average S. 65° E.; here again is a distinct example of concomitant variation, and we must conclude even with more confidence than before that the rain area and the course and velocity of our storms are intimately connected.

So great has been the scientific interest in these studies, which Professor Loomis has now for over ten years presented to the semi-annual meetings of our National Academy of Sciences, that they have been translated abroad, and to them more than to any other source must the inquirer turn for information on this growing subject.

I have intentionally called this lecture a review of "*Some* American Contributions to Meteorology," in order to emphasize the manifest fact that many contributions remain unmentioned. The diligent student will find much instruction and entertainment in completing the review here begun.

November, 1888.

INDUSTRIAL APPLICATIONS OF COTTON-SEED OIL.

By ROBERT GRIMSHAW (Member of the INSTITUTE).

[*Read at the Stated Meeting of the* FRANKLIN INSTITUTE, *December 19, 1888.*]

JOS. M. WILSON, President, in the Chair.

Mr. GRIMSHAW:

In these days there is no industry in which the main product should be considered alone; the by-products, what they are and what may be done with them, are very often almost equally important.

Glycerine, pyroligneous acid, and a hundred other important products, have for us an importance far beyond that which was at first claimed for them. The one a waste article, the other at first made only by direct process, we find the waste of yesterday the valuable commodity of to-day, while the manufacture of fine charcoal for gunpowder making, produces pyroligneous and acetic acids which are worth more than the charcoal.

So is the case of the cotton-seed oil (itself formerly a by-product in the manufacture of meal from the cotton seed, this in its earlier turn a cumbersome residue of an important

industry), the question must arise what is left after the oil is expressed; and what may be made from this residuum; what are the substances left in the purification of the oil itself, and what may be done with them?

The uprising of humility is as strongly illustrated in the case of the cotton seed as in the tale of "Cinderella." Long considered a refuse for which there was no use; long burned or thrown away, its main and by-products are now very important elements in our national industries. The garbage of 1800 became the fertilizer of 1870, the cattle food of 1880, and is now made to yield table food and useful articles of industrial pursuits.

To-day we have in the oil the main product; in the residuum after its expression a valuable fertilizer, and the best cattle food; in the hulls, excellent fuel; in the ashes of these hulls, potash of high commercial value, and in the refuse most excellent stock for laundry and toilet soaps.

Cotton oil is used for a great variety of purposes, and probably at the present time it is more widely known throughout the world and used for a greater variety of purposes than any other oil.

In the United States it is made from the decorticated and crushed upland cotton seed, by expression, this process yielding an odorless dark brownish-green oil having a specific gravity of about ·9224. Being then treated with alkaline solutions (generally containing potash or soda), the clear yellow oil, which is odorless and flavorless and has the same specific gravity as the crude, is drawn off by racking, and the residuum, which is called soap stock, is treated in a suitable manner.

The refined oil boils at about 600° F. and congeals at about 50° for summer- and 32° for winter-pressed.

The American seed yields a clearer oil than the Egyptian or the Indian; and that from our sea-coast a darker oil than that from the uplands. The oil made in Great Britain is not so clear as ours, because the seed there treated is Egyptian or Indian, and is not decorticated, owing to the difficulty of picking it; our American cotton parting with its fibre in a more satisfactory manner, and generally yielding

better to treatment. The section of country also has much to do with the quality of the oil, as do also the weather and the season. Some years, owing to more favorable weather, Texas oil will be the best, and others, Tennessee. In some seasons, owing to more favorable weather, the oil obtained from the seed grown in the western sections of the cotton belt, is superior to that grown in the eastern part, while in other years the eastern states yield a better quality of oil.

The present consumption of cotton seed for oil-making purposes is about 800,000 tons a year, from which there are made about 28,000,000 gallons, worth about thirty cents per gallon in the refined condition.

The principal use to which it is put is for food purposes. The well established fact that it is not only healthful, but more easily digested than almost any other article of food, accounts for the rapid increase of its use for culinary purposes, which to-day amounts to a very large proportion of the entire production. It is safe to say that of the 28,000,000 gallons made each year, nine-tenths enter into the composition of food products, principally refined lard and salad and cooking oil. It is also used for illuminating; in the manufacture of nuts and bolts; for wool soap; for soap for laundry, bath and toilet purposes; as an emulsion in medicine, to take the place of olive oil; as a substitate for cod-liver oil; in packing sardines, and for dozens of other purposes as a substitute for olive oil.

Its lubricating properties are poor, as it comes in between the drying and the non-drying oil. This debars its use as a lubricant either for journals or for steam cylinders.

By reason of its non-drying properties it cannot be used as a wood filler; nor for stuffing hides in the manufacture of morocco and other leathers.

As there is nothing which can be added to it to make it "drying," it is for the same reason debarred from use as a menstruum for paints.

It has been used to some extent as a cosmetic, to take the place of vaseline and similar substances. Woollen mill soap made from cotton-seed oil is claimed to be superior to all others, and is now the principal soap used by the

woollen mills of this country, being also extensively employed in England, Scotland and elsewhere. The oil is also used for making laundry and all descriptions of family and fancy soaps.

From the soap stock there is made a washing powder which, although not strictly one of the products of the cotton oil itself, owing its principal virtues to the soda and potash used in the refining process, and which are thus utilized, are nevertheless by-products in the manufacture.

From the seeds, after the oil has been expressed, there is made an oil-cake, which is an excellent food for stock.

The ashes from the hulls are a very good fertilizer for sugar-cane and for root crops, and are so used extensively.

As an illuminant it ranks between sperm, which has the highest illuminating power of all the burning oils, and lard, which is about the next best; there being about twenty-five per cent. difference in the candle-power of sperm and lard oils, while cotton-seed oil comes in about half way between them. Alone, it may be burned in any of the ordinary lamps used in burning either sperm or lard oils. It may be mixed with petroleum in slight proportions to increase its freedom of burning; this requiring some modification of the lamp employed.

There are on the coast of Maine a great many establishments which put up what are known variously as sardines and "shadines," being young shad and herring put up as are the true sardines of Sicily and the south coast of France. All of these are cooked, and most of them put up in boxes, with cotton-seed oil; and of the immense quantity of true sardines put up in France and other European countries, nearly nine-tenths are now done with cotton-seed oil instead of with olive as formerly.

Among other uses for which cotton-seed oil would be likely to be available may be mentioned the manufacture of perfumes as an extractive from flowers, candle making and steel tempering.

But it is perhaps in the manufacture of refined lard that cotton-seed oil finds its principal use. It has been employed for this purpose for about forty years; being at first

employed to temper down stock which was intended for sale to very cold climates and which for that reason required to have its chilling or stiffening point lowered. Its excellence for this purpose being known, and taken in connection with its cleanliness of source and manufacture, and high nutrient powers, its use became more general, and it was used in lard for temperate climates, its extreme fluidity being corrected by the use of a sufficient proportion of pure caul fat of the beef. So popular did this admixture in refined lard become, and the preference soon setting in so strongly in favor of those refined lards containing cotton-seed oil and beef fat in considerable proportion, that at last a lard was prepared especially for the use of Isrealites, whose religion wisely prohibits the use of any product of the hog, and who had for a long time employed pure refined yellow summer cotton-seed oil for salad dressing and for cooking. The filthy and unscrupulous practice of some of the lard packers, in running into the prime lard tanks every portion of the hog, has led many who have no religious scruples against any product of the hog, and who wish for something which should be free from unclean materials or revolting suggestions and associations. A third reason adduced in favor of the cotton-seed oil lard is that it is anti-dyspeptic; while it is claimed that only about three-fifths as much is needed to produce the same results as by hogs' lard. It is safe to say that three-fourths of all lard made and used contains cotton-seed oil, in proportions from ten to twenty-five per cent; most of it avowedly; while for many years, leading houses used it secretly, from fear of popular prejudice. At present the tide of public opinion seems to be setting in favor of its use; and the principal refiners not only admit that they use it, but take pains to have that fact known, as an argument in favor of the purity, cleanliness and healthfulness of the product.

The refined lard of thirty-five or forty years ago was made by pressing out from the regular lard about fifty per cent. of the oil that it contained, leaving the stearine, which was combined with that lard. What was left was sold as lard. This naturally made an accumulation of stearine.

Later that stearine was mixed with ordinary lard so as to make the latter firmer, so that it would answer better for exportation to warm climates. As the "shortening" of lard is in the stearine and not in the oil, this lard with which stearine was mixed answered better for cooking purposes than the natural product, and sold at a higher price than the latter. It was known as "refined," the term being a misnomer.

In the old-fashioned manufacture of lard the leaf and trimmings were put in kettles, and the lard tried out by heat applied outside the kettle. This made "prime kettle-rendered lard." Later it became the custom to try out the lard by injecting the steam into the kettle itself, so as to come in contact with the lard and the other materials; the result being that the water and steam dissolved out the gelatinous portions, so that they could be removed, leaving the lard whiter and purer than the kettle-rendered, in which latter the darker gelatinous portions were to a considerable extent dissolved by and contained in the product.

The head and gut fat were rendered together, making "No. 1" lard; then there were various greases, white and yellow, made from the other portions of the animal. The grease was very largely used in making No. 1 and No. 2 lard-oil, for lubricating.

Later the packers "went the whole hog," putting in trimmings and heads and all, making but one "straight" brand, known as "steamed lard." There came a time when the butterine men consumed all the leaf lard that was made, grinding it up and putting it in water at about 112° to get out the fat that they used for their product. This was known as "neutral" lard. Its withdrawal from the prime steam lard lowered the quality of that product, and left it with a bitter taste. To supply the place of the leaf lard which was taken out, and to correct the bitter flavor of the prime steam lard, packers commenced the addition of cotton-seed oil, a pure vegetable product, sweet in taste and smell, and healthful in itself. But it made the lard too soft. To overcome that disadvantage, it was found desirable to use "oleo-stearine" from beef suet. The suet fat was

pressed, and the oil from that, called in the trade "oleo," used in the manufacture of oleomargarine; the stearine left from the pressure being used to harden the lard already softened by the cotton-seed oil.

The "refined lard" of commerce is to-day made of three ingredients: (1) refined packers' lard; (2) pure pressed beef fat (oleo-stearine) and (3) pure refined cotton-seed oil. The beef fat which has too much consistency, is balanced by the cotton-seed oil, which has hardly enough for ordinary temperatures; but both are pure, both are clean, both are nutritious.

One reason for using beef fat is, that hogs' lard has a strong odor which is necessary to tone down by admixture with some other fat or oil. Pure hogs' lard has the disadvantage of not keeping well; rapidly becoming soft and rancid in the merchant's store. Of course it is desirable, if not imperative, that such materials as are added be pure, healthful and nutritious.

There are about twenty-five manufactories of refined lard, containing (in addition to hogs' lard) beef fat and cotton-seed oil; and some concerns use no hogs' lard at all; these being most open in their avowal of the fact, and claiming for their product that it is better than that containing hogs' lard as the principal or secondary ingredient.

Some of the reasons adduced why hogs' lard, as ordinarily made, should not be used, are that the hog is liable to various diseases which may be transmitted to the human system; that in its manufacture by many of the packing houses cleanliness and proper care are not always used; that competition offers a temptation to unscrupulous dealers to buy and use smothered or diseased hogs, and that dirty and objectionable parts of the animal are used.

There was a time when from certain selected portions of corn-fed home-raised hogs there was made, by simple and ordinary domestic process, a lard which was perhaps entirely free from any objectionable features. At present, hogs fed on swill and on distillery grains form a large percentage of those which are killed and packed; many diseased animals are used; the head, feet and entrails, as well as unnameable

parts, are thrown into the rendering tanks to be made into "prime lard," instead of into "white grease;" so that what might be admissible, unchallenged, as an article of food, if properly prepared from pure wholesome materials, is now very open to suspicion. That these are not old wives' tales may be very clearly seen by the testimony brought out at the sitting of the Committee on Agriculture of the House of Representatives, at Washington, in March of 1888. Much of this testimony is so disgusting and revolting that it would be very much out of place in a paper read before a mixed audience.

James Matthews testified, on March 20th of this year, that at the packing house where he worked for several years in making "pure" lard, they put in the pigs' heads, then the feet, then the rough lard and white grease; that there was hair on the heads and hoofs and toes on the feet, and that the white grease was made from guts and paunches and unmentionable parts.

Abram S. Jewell testified, March 2d (page 97), that the white grease was made from sore parts of hogs and hogs which had been smothered in the cars or had died from unnatural causes.

Other witnesses, familiar with the details of the business, and many of the workmen in the packing houses, testified in corroboration of these statements, and also said that crippled and sickly animals and "piggy" sows and those which had dropped their pigs in the cars, were put right into the lard tanks, the same as healthy ones.

The testimony of distinguished analysts and authorities is to the effect that cotton-seed oil is not only perfectly harmless, but more wholesome than hogs' lard. From a mass of such expert opinions, I extract the following:

Extracts from Testimony of Prof. H. W. Wiley before the Committee of Agriculture, United States Senate, Washington, D. C., March 17, 1888.

Q. What would you say of cotton-seed oil when used alone as an article of food?

A. I should say that it was perfectly wholesome.

Q. As wholesome as olive oil or hog fat or lard?

A. Yes, sir.

Q. Or beef fat?

A. Yes, sir; that is, as far as our knowledge of the subject extends.

Q. What relation, so far as you know, does cotton-seed oil bear to olive oil?

A. It is very nearly identical.

Q. From your knowledge of chemistry and also of medicine, please tell us whether there is any property in cotton-seed oil injurious to health?

A. Not so far as I know.

Q. Does that statement also apply to beef stearine used in connection with cotton-seed oil in the manufacture of refined lard?

A. Yes, sir. So far as I know, there is nothing in it injurious to health.

Q. You have stated that, so far as you know, this cotton-seed oil has no property that is injurious to health?

A. That is what I stated.

Q. Are the nutritive qualities of cotton-seed oil equal to the nutritive qualities of pure lard?

A. I should say there would be very little difference as far as nutritive properties are concerned.

From

"FOOD ADULTERATION,"

By

JESSE P. BATTERSHALL, Ph.D., F.C.S., Chemist United States Laboratory, New York City, 1887.

As a result of the publicity lately given to the subject of food adulteration, a popular impression has been produced that any substance employed as an adulterant of, or a substitute for another is to be avoided *per se*. Perhaps the common belief that for all purposes cotton-seed oil is inferior to olive oil, and oleomargarine to butter, is the most striking illustration of this tendency. Now, as a matter of fact, pure cotton-seed oil, as at present found on the market, is less liable to become rancid than the product of the olive, and, for many culinary uses, it is at least quite as serviceable. The sale of these products, under their true name, should not only be allowed, but under some circumstances encouraged.

[From *Medical Classics*, New York, December, 1887.]

When, for instance, it becomes understood that the addition of cotton-seed oil to lard is a step in the direction of wholesome and nutritious food and costing the consumer much less than the natural product, a great step forward will have been taken.

The magnitude of the lard industry of the United States may be well imagined, when it is understood that the exports alone in 1887 were 321,523,746 pounds, valued at $22,703,921.

The output of one lard house only (that of N. K. Fairbank & Co.) was, in 1887, 162,847,211 pounds, and will reach this year, 1888, about 200,000,000 pounds. The refined lard industry of this country represents about $15,000,000 per annum, and the cotton seed and cotton-seed oil product, at least $16,000,000. The refuse of a generation ago is now not only an important food for mankind and domestic animals in two hemispheres, but a valuable household cooking material and table delicacy.

Cotton-seed oil-cake is consumed not only in America, but in Great Britain, Germany, Denmark, Norway and Sweden. It is one of the best known animal foods, and has a higher value than any other article, not only for producing milk, fat, bone, etc., but also for manurial uses.

For the purpose of determining the relative and actual values of nitrogenous and non-nitrogenous foods upon the fat and the lean meat of the hog, many careful tests have been made by Profs. W. A. Henry, of the University of Wisconsin, and J. W. Sanborn, of the Missouri Agricultural College. Their experiments showed what might have been suspected: that the nitrogenous food produced the most muscle and the non-nitrogenous the most fat.

The same character of tests were made upon lambs, and the results of these experiments are published by the Agricultural Experiment Station of Cornell University, in its *Bulletin* No. 2, for August, 1888, from which I extract the following facts:

> Six six-months' old lambs were taken; and three fed upon oil meal and coarse wheat bran, and later upon cotton-seed meal, oil meal and bran; the other lot of three being given corn meal. Both were fed, during the test, with mixed timothy and clover hay.
>
> It was found that the effect of feeding an undue proportion of non-nitrogenous food to sheep was
>
> (1) To decrease the production of wool by one-fourth;
> (2) To decrease the strength of the bones by one-third;
> (3) To reduce the production both of fat and of lean meat.

Cotton-seed meal as a food for cattle largely increases the flow of milk, makes richer milk, gives butter and cheese; more and better meat, and richer manure.

Its main value is due to the fact that it supplies the albuminoids and fats which, in hay, straw, corn-stalks and the like, are lacking. It makes rich manure and it may be used to add to poor foods the albuminoids which they lack.

The annexed table, giving the water, ash, digestible nutrients, nutritive ratio, and money feeding-value of various American feeding stuffs, is taken from *Feeding Animals*, by E. W. Stewart.

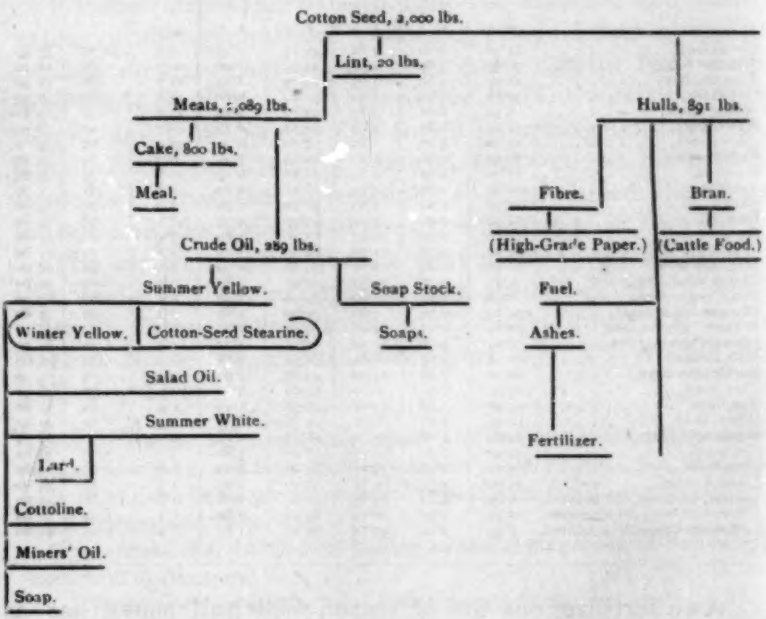
Kind of Food.	Water.	Ash.	Digestible Nutrients.			Nutritive Ratio.	Feeding Value.	
			Albuminoids.	Carbohydrates, Including Fibre.	Fat.		Value per 100 Lbs.	Value per ton of 2,000 Lbs.
	p. c.	*p. c.*	*p. c.*	*p. c.*	*p. c*	*as 1.*		
Clover hay,	12·56	6·10	7·82	40·25	1·49	5·6	$0 77	$5 40
Meadow hay,	10·50	5·80	4·38	44·55	1·06	10·7	62	12 40
Timothy hay,	11·07	4·06	3·67	41·25	1·03	12·7	62	12 40
Oat straw,	9·62	5·20	1·44	42 62	0·66	30·6	47	9 40
Wheat straw,	6·50	6·96	0·85	37·70	0·54	45 8	39	7 80
Rye straw,	11·11	1·84	0·95	37 55	0·54	41·0	40	8 00
Corn stalks,	15 00	4·02	1 10	37·00	0·30	34·4	39	7 80
Fodder beets,	88·00	0·80	1·10	10·00	0·10	9·3	14	2 80
Potatoes,	75·00	0·90	2·10	21·80	0·20	10 6	29	5 80
Turnips,	92·00	0·70	1·10	6·10	0·10	5·8	11	2 20
Barley,	14·30	2·20	8·00	58·90	1·70	7·9	95	19 00
Oats,	14·30	2·70	9·00	43·30	4·70	6·1	98	19 60
Rye,	14·30	1·80	9·90	65·40	1·60	7·0	1 08	21 60
Wheat	14·40	1·70	11·70	64 30	1·80	5·8	1 13	22 60
Sorghum seed,	12·52	1·80	6·84	53·06	2·99	8·5	90	18 00
Gluten meal, dry,	9·15	0·78	23·30	30·92	3·80	2·5	1 63	32 60
Dried sugar meal,	8·50	2·00	10 20	54·50	5·40	5·4	1 16	23 20
Glucose sugar meal,	72·20	0 10	3·20	19·30	1·80	7·4	39	7 80
Brewers' grains, wet,	75·00	1·01	4·06	9 73	1·41	3·2	32	6 40
Brewers' grains, dry,	8·19	3·58	14·32	37·41	4·77	3·3	1 20	24 00
Malt sprouts,	10·28	5·67	18·82	52·95	0·88	2·3	1 33	26 60
Buckwheat bran,	14·00	3·40	13·30	44·00	3·90	4·1	1 15	23 00
Corn bran,	12·00	2·30	6·20	55·00	3·60	10·3	92	18 40
Rye bran,	11·48	3 68	12·00	48·98	1·43	4·4	89	17 80
Wheat bran,	12·42	5 68	11 72	44·66	2·58	4·4	1 02	20 40
Wheat middlings,	12·00	3·18	11·60	48·87	2·68	4·7	1 00	20 00
Pea meal,	11·40	3 50	20·90	55·40	2·80	3·0	1 53	30 60
Corn meal,	15 19	1·48	7·27	63·40	3·29	9 8	1 03	20 60
Linseed cake,	10·00	5·97	29·04	33·09	4·53	1·5	1 75	35 00
Linseed-oil meal, old process,	9·20	5 87	25·85	26 52	7·08	1·6	1 66	33 20
Linseed-oil meal, new process,	10·75	5·57	28·25	27·95	2·80	1·3	1 54	30 80
Cotton-seed meal decorticated,	8·33	7·25	35·75	92·25	11·65	1·4	2 25	45 00

As a fertilizer one ton of cotton-seed hull ashes has as much value as four and one-half of average hard wood ashes or fifteen of leached hard-wood ashes.

Two years ago, Messrs. Joseph Sears and Oliver Burnham, of Chicago, started to work out a process to utilize the hulls which were being thrown away or else used as fuel to

run the boilers of the air mills. After long and patient experiment and the expenditure of a large sum of money, they at last have perfected a machine which is now running in St. Louis and is now supplying paper mills with a fibre which comes next to the best of linen in the quality of paper it produces. The fibreless husk, after separating the lint, makes a valuable cattle food. Being rich in carbohydrates it is an excellent material to feed with cotton-seed meal, distillery grains and similar material having too high a nutritive ratio. It is giving the greatest satisfaction and the mill cannot supply the demand. The same is true of the demand for fibre.

The following diagram illustrates the gradual division of the products from a ton of seed:



And now, in conclusion, if I have brought out in this connection any facts or figures which are new and interesting; if I have pointed out with some emphasis the importance and proportions of the industries which have arisen in con-

nection with what was once a waste, a so-called worthless product; and if in so doing I have in any way encouraged earnest and original-minded men to seek in the wastes of to-day, wealth for themselves and valuable products and processes for the millions' use—the time which I have devoted to the preparation of this paper and that which you have so courteously awarded its reading, will have been well spent.

THE DEBT OF MEDICAL AND SANITARY SCIENCE TO SYNTHETIC CHEMISTRY.

BY PROF. SAM'L P. SADTLER, PH.D.

[*A Lecture delivered before the* FRANKLIN INSTITUTE, *January 28, 1889.*]

The lecturer was introduced by Dr. PERSIFOR FRAZER, Professor of Chemistry in the INSTITUTE, and spoke as follows:

MEMBERS OF THE INSTITUTE, LADIES AND GENTLEMEN:

Writers on the history of chemistry record the existence of a class of *Iatro-chemists*, who succeeded the alchemists proper, and paved the way for the emergence of chemistry as a distinct branch of science from the mists of alchemy. These were medical men who, seeking for additions to their materia medica, turned their time and attention to the pursuit of chemistry. So it comes about that chemistry undoubtedly owes its earliest cultivation, if not its birth, to the followers of the medical profession. Its debt of gratitude for this it has from time to time endeavored to repay in instalments, but is now preparing to square up any balance due, by turning all the resources of modern synthetic methods toward the manufacture of new remedies of therapeutic value. Perhaps the busy physician may say that, if he has to master the nomenclature of modern organic chemistry in order to avail himself of the use of these compounds, it is a doubtful

blessing. But here steps in the enterprising manufacturer and patentee, who coins for him (and copyrights for himself) such suggestive words as "antipyrine," "antifebrine," "aseptol" and "saccharin," and thus allows the practitioner, if he so desire, to prescribe the new remedy without mastering either the chemical formula or the scientific name of the compound.

While the materia medica of the medical profession has been for many years predominantly organic, as distinguished from inorganic or mineral in character, these organic compounds have been taken almost exclusively from the vegetable kingdom. Chemistry has only been asked to perform the minor service of extracting these plant principles and purifying them for use as medicines.

The artificial manufacture of medicinal chemicals was confined to a few important compounds, chiefly anæsthetics, like ether, chloroform and chloral hydrate. The additions to the list of medicinal chemicals of artificial or synthetic manufacture have been so numerous, however, in the last few years, that it seemed desirable to present a classified enumeration of the more important of them, or at least of those in the classes of anæsthetics or hypnotics, antiseptics, analgesics and antipyretics. I have therefore selected this as my subject for this lecture, and will endeavor to group, from the chemical point of view, some of the newer of these compounds, and to look at the question as to whether any correspondence can be made out between chemical grouping and therapeutic action.

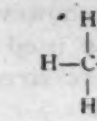
I have put, in Class I, all the derivatives of methane, including with the newer ones, ether, chloroform, iodoform and chloral hydrate for comparison; in Class II, phenols and allied compounds; in Class III, other phenyl derivatives; in Class IV, pyrrol derivatives; and in Class V, quinoline derivatives.

Class I—Methane Derivatives.

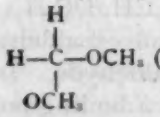
Methylene dimethylic ether (methylal), . . .	$CH_2(OCH_3)_2$
Ethylidene diethylic ether (acetal), ...	$CH_3CH(OC_2H_5)_2$
Tertiary amyl alcohol (amylene hydrate), . .	$(CH_3)_2C(C_2H_5)OH$
Paraldehyde, ...	$(CH_3CHO)_3$
Ethyl carbamate (urethane), ...	$CO\begin{cases}NH_2\\OC_2H_5\end{cases}$

Diethyl sulphon-dimethyl-methane (sulphonal),	$(CH_3)_2C.(C_2H_5SO_2)_2$
Ethylic ether,	$(C_2H_5)_2O$
Methylene chloride (dichlor-methane),	CH_2Cl_2
Chloroform (trichlor-methane),	$CHCl_3$
Iodoform (triiodo-methane),	CHI_3
Chloral hydrate,	CCl_3CHO+H_2O
Butyl-chloral hydrate (croton chloral),	$C_3H_4Cl_3CHO+H_2O$
Ethylene chloride.	$C_2H_4Cl_2$

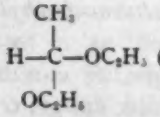
The relationship of these, apparently somewhat diverse, compounds, is more clearly seen if we express them in graphic formulæ, alongside of the formula of methane.



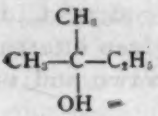
(Methane).



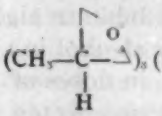
(Methylal).



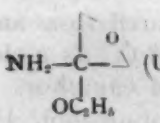
(Acetal).



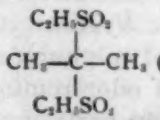
(Amylene hydrate).



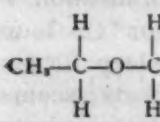
(Paraldehyde).



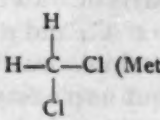
(Urethane).



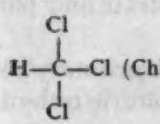
(Sulphonal).



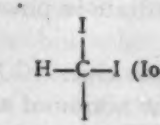
(Ether).



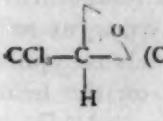
(Methylene chloride).



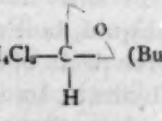
(Chloroform).



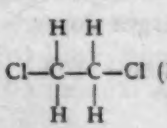
(Iodoform).



(Chloral).



(Butyl chloral).



(Ethylene chloride).

NOTES ON THE CHEMICAL AND THERAPEUTIC CHARACTERS OF COMPOUNDS IN CLASS I.

(1) *Methylene Dimethylic Ether* (Methylal). $CH_2(OCH_3)_2$.—Is made by distilling methyl alcohol with sulphuric acid in the presence of maganese dioxide. Is a colorless liquid, sp. gr. 0·855 at 17° C., boils at 42° C., and has an odor resembling that of chloroform and acetic ether, with warm, aromatic taste. Is soluble in alcohol, ether and in three parts of water. Its vapor is not inflammable. It is a soporific, producing quiet sleep. The patient, however, becomes rapidly used to it, so that it must be used in increasing doses. Is claimed to be an antidote to strychnine poisoning when hypodermically used.

(2) *Ethylidene-diethylic Ether* (Acetal). $CH_3CH_2(OC_2H_5)_2$.—Is obtained as a by-product of the alcohol or aldehyde manufacture, or can be made direct from aldehyde. Is a limpid liquid, sp. gr. 0·821 at 22° C., and has a boiling-point 104° C. Is soluble in eighteen parts of water at 25° C., but miscible with alcohol in all proportions. Is given internally as a narcotic, in doses of one and one-half to two and one-half drachms (five to ten grammes).

(3) *Amylene Hydrate.* $C_5H_{11}OH$.—Is prepared from amylene C_5H_{10} and sulphuric acid and water at 0° C. Is a clear fluid, with an odor reminding one slightly of camphor. Is soluble in eight parts of water; also soluble in alcohol. Has a sp. gr. 0·812 at 12° C., and a boiling-point 102° C. Is used as a soporific, one fluid drachm producing sleep for six to eight hours without unpleasant secondary effects; seems to be intermediate in power between chloral hydrate and paraldehyde.

(4) *Paraldehyde.* $(C_2H_4O)_3$.—Is formed from ordinary aldehyde, by the action of small quantities of sulphuric or hydrochloric acids or salts like $ZnCl_2$ at ordinary temperatures. Is a colorless liquid, boiling at 124° C., sp. gr. 0·9943 at 20° C. Requires twelve parts of water for solution. Is a hypnotic like chloral hydrate, but not so depressing on the heart; also acts as an anæsthetic in larger doses.

(5) *Ethyl Carbamate* (Urethane). $CO\left\{\begin{matrix}NH_2\\OC_2H_5\end{matrix}\right.$.—Is made

by the action of ammonia upon ethyl carbonate, urethane and ethyl alcohol being formed, or by heating urea nitrate and alcohol to 120° to 130° C., when ammonia is given off. It forms colorless crystals of slight ethereal odor and tastes like saltpetre; is soluble in water and alcohol. Melts at 47° to 50° C., and boils without decomposition at 180° C. Is used as a soporific, but does not produce a comatose state like chloral hydrate. Is said to be specially adapted for use as a soporific with children.

(6) *Sulphonal.* (Diethyl Sulphon-dimethyl-methane). $(CH_3)_2C(C_2H_5SO_2)_2$.—Forms heavy colorless prismatic crystals, melting at 125°·5 C.; not very soluble in cold water, more readily in boiling water, in alcohol and alcoholic ether. Is a hypnotic of value, especially in the insomnia of the insane and similar cases.

(7) *Methylene Chloride.* CH_2Cl_2.—Is a colorless liquid, having a chloroform-like odor and neutral reaction. Is soluble in alcohol and ether. Was first introduced by Dr. B. W. Richardson, some years ago, as an anæsthetic, but was impure, and several deaths followed its use. Latterly, having been obtained quite pure, it has been successfully reintroduced. It has a sp. gr. 1·349 at 14° C., and boils at 40° C. It is pleasant to inhale.

(8) *Butyl Chloral Hydrate.* $C_3H_4Cl_3CHO + H_2O$.—Is prepared by passing chlorine into acetaldehyde, until it ceases to be absorbed, and then rectifying and collecting that fraction boiling at 163° to 165° C. This is crystallized with water. Forms white scales of a silky lustre, a peculiar fruit-like odor, warm, bitterish taste and neutral reaction. It melts at 78° C., and is freely soluble in alcohol, ether, glycerine and hot water. It is a valuable hypnotic, producing quiet sleep without impairing the muscular tone of the body.

(9) *Ethylene Chloride.* $C_2H_4Cl_2$.—This is rather taken as representative of a class of chlorinated bodies, which includes, besides this compound, *ethyl chloride*, C_2H_5Cl; *ethylidene chloride*, CH_3CHCl_2 (isomeric with ethylene chloride, $CH_2Cl.CH_2Cl$) and *carbon tetrachloride*, CCl_4. These all possess hypnotic and, in some degree, anæsthetic properties, but have not met with general acceptance, because of apparent injurious after-effects.

If now an effort be made to find some connection between chemical constitution and therapeutic effect, we at once step upon uncertain ground. The systematic testing of the several classes of methane derivatives has not been carried far enough to enable us to speak with much certainty as to the effect of the compounds as classes, and above all, in many cases, the compounds tried have not always been chemically pure. The chlorinated side-products of the chloroform made from alcohol afford an illustration of this. Unless a substance can be purified by recrystallization, as in the case of chloral hydrate, or be gotten of absolutely fixed and uniform boiling-point, we have no assurance of its purity.

Still we can recognize several general features in studying the structural formulæ of the compounds already described. The chlorinated derivatives of methane all show hypnotic character, advancing in the case of several to the character of anæsthetics, which, however, may or may not be accompanied by other effects which limit their safe application.

The introduction of the methyl and oxymethyl groups (CH_3 and OCH_3) and the ethyl and oxyethyl groups (C_2H_5 and OC_2H_5) in place of the hydrogen of the methane molecule apparently gives us also compounds of hypnotic character, as illustrated in methylal, acetal, amylene hydrate, sulphonal and urethane.

These slight indications, which, as said, must be taken with reserve, may then serve to point out some other compounds as possessing in all probability analogous therapeutic character. Thus, both the methyl and the ethyl orthoformic ethers, $CH(OCH_3)_3$ and $CH(OC_2H_5)_3$, and what is known as tribasic acetic ether, $CH_3C(OC_2H_5)_3$, are sufficiently analogous to methylal and acetal to have similar effects; trichloracetal, $CCl_3CH(OC_2H_5)_2$, stands in chemical composition related to both acetal and to chloral and should have analogous character; tertiary butyl alcohol, $(CH_3)_3COH$, should be analogous to amylene hydrate (tertiary amyl alcohol). As said, these are probabilities, but some of them may fail. The old adage says: "The proof of the

pudding is in the eating of it," and until they are tried, we cannot speak with any certainty.

CLASS II.—PHENOLS AND ALLIED COMPOUNDS.

Phenol (carbolic acid),	$C_6H_5(OH)$
Cresol (cresylic acid),	$C_6H_4(CH_3)OH$
Resorcin (metadioxybenzol),	$C_6H_4(OH)_2$
Hydroquinone (paradioxybenzol),	
Thioresorcin,	$C_6H_4(SH)_2$
α-Naphthol,	$C_{10}H_7OH$
β-Naphthol,	
Tribromphenol,	$C_6H_2Br_3OH$
Trichlorphenol,	$C_6H_2Cl_3OH$
Salicylic acid,	$C_6H_4(OH),COOH$
Phenyl salicylate (salol),	$C_6H_4(OH),COOC_6H_5$
β-Naphthyl salicylate (betol),	$C_6H_4(OH),COOC_{10}H_7$
α-Oxynaphthoic acid,	$C_{10}H_6(OH),COOH$
Orthophenol-sulphonic acid (aseptol),	$C_6H_4(HSO_3),OH$
Di-iodophenol-sulphonate (soziodol),	$C_6H_2(HSO_3)I_2OH$

These compounds all contain the phenol group (OH) with the exception of thioresorcin, in which the corresponding SH group replaces it. They do not exhaust the list of phenol-like bodies, as creasol and quaiacol of wood tar, thymol contained in several essential oils and pyrocatechin and pyrogallol might be included, but the list has been limited to strictly synthetic compounds of medicinal or sanitary value.

NOTES UPON THE CHEMICAL AND THERAPEUTIC CHARACTER OF COMPOUNDS IN CLASS II.

(1) *Cresol* (Cresylic Acid). $C_6H_4(CH_3)OH$.—Accompanies phenol or carbolic acid in coal tar. As extracted from coal tar, it is a mixture of the three isomeric cresols, and has a sp. gr. of 1·039 to 1·044. It differs from carbolic acid in being liquid, less soluble in water and boiling at a higher temperature. It is claimed for cresylic acid that its antizymotic action is superior to that of carbolic acid, one part of a two per cent. solution added to ten parts of a fermenting liquid stopping all further fermentation.

(2) *Resorcin* (Metadioxybenzol). $C_6H_4(OH)_2$.—When pure forms white crystals with a faint odor and sweetish, acrid

taste. Is easily soluble in water, alcohol and ether. Is used both externally and internally as an antiseptic and anti-fermentative, being free from the highly toxic character of phenol.

(3) *Hydroquinone* (Paradioxybenzol). $C_6H_4(OH)_2$.—Forms colorless prisms soluble in seventeen parts of water at 15° C., more readily soluble in alcohol and ether. It melts at 169° C. Is changed to quinone by the action of oxidizing agents. It is claimed for it that in many instances it is to be preferred to resorcin, as it reduces temperature in much smaller doses, and is the foremost of the antiseptic and anti-fermentative phenols. It has recently been introduced into photography as a substitute for pyrogallol.

(4) *Thioresorcin.* $C_6H_4(SH)_2$.—Yellowish-gray flocculent powder. Is insoluble in ordinary solvents, soluble freely in solutions of the alkalies, alkaline carbonates and alkaline sulphides. Powerful and non-irritant antiseptic. Is used also as a substitute for iodoform.

(5) *α-Naphthol.* $C_{10}H_7OH$.—Crystallizes in shining needles, melts at 95° C., boils at 278° to 280° C., and readily volatilized. Is prepared from α-naphthylamine or from α-naphthalene-sulphonic acid. Is an antiseptic of extraordinary efficiency in hindering the development of pathogenic micro-organisms. Its anti-zymotic effect in preventing the alcoholic fermentation in glucose solutions is very strong. (1 : 10·000 of glucose).

(6) *β-Naphthol.* $C_{10}H_7OH$.—Occurs in colorless or grayish silky leaflets with faint phenol-like odor and burning taste. Melts at 123° C., and boils at 286° C. Is not very soluble in cold water, but much more soluble in hot, readily soluble in alcohol, ether, benzol, chloroform and in alkalies. Is used as an antiseptic and for external application in skin diseases.

(7) *Tribromphenol.* $C_6H_2Br_3OH$.—Soft white needles, melting at 95° C., and subliming unchanged at higher temperatures. Soluble in alcohol, ether and chloroform, not in glycerine. Readily soluble in caustic alkalies from which it is separated unaltered by acids. Is used as an antiseptic dressing and disinfectant in purulent and gangrenous pro-

cesses. According to experimenters it does not cauterize the mucous membranes of the mouth, nose or pharynx.

(8) *Trichlorphenol.* $C_6H_2Cl_3OH$.—Is the chief product of the action of chlorine upon phenol. Forms needles, melting at 68° C., and boiling at 244° C. Is easily soluble in alcohol and ether. Used for antiseptic dressings and as a germicide. Also, used in Germany very effectively for erysipelas. Its antiseptic power is said to be twenty-five times as great as that of phenol.

(9) *Salicylic Acid.* $C_6H_4(OH),COOH$.—Is now made by Von Heyden's successors, under Kolbe's patent, as improved by Schmidt, C_6H_5ONa (sodium phenol) + $CO_2 = C_6H_4ONa$ COOH (sodium phenol-carbonic acid). This later compound, when heated to a temperature of 140° C. under pressure, undergoes molecular rearrangement and yields $C_6H_4(OH)$ COONa (sodium salicylate) from the solution of which the acid is precipitated by hydrochloric acid. Salicylic acid is used both as such and as sodium salt. Used both internally and as antiseptic for water, milk, meats and foods.

(10) *Phenyl Salicylate* (Salol). $C_6H_4(OH),CO\,OC_6H_5$.—Is made by the combination of salicylic acid and phenol. Forms a white tasteless powder of faint aromatic odor, insoluble in water, but soluble in alcohol. It seems to combine the qualities of phenol and salicylic acid, and it is supposed that these substances are liberated from it by the decomposing influence of the pancreatic juice. It is used in rheumatism, neuralgia, and is also a powerful antipyretic and antiseptic.

(11) *β-Naphthyl Salicylate* (Betol or Naphthalol). C_6H_4 $(OH),CO\,OC_{10}H_7$.—Is a compound analogous to salol, but obtained from β-naphthol and salicylic acid. Is in white micaceous scales, melting at 95° C., nearly insoluble in water, easily soluble in boiling alcohol, odorless and tasteless. Is not decomposed by acids or the gastric juice, but, like salol, is decomposed by the pancreatic juice. Is analogous in uses to salol, but not so widely useful.

(12) *Orthophenol-Sulphonic Acid* (Aseptol). $C_6H_4(HSO_3)$, OH.—Is a pinkish or yellowish liquid, having an odor resembling carbolic acid, and a gravity of 1·45. It is readily

soluble in water, alcohol and glycerine. The trade-name "aseptol" is given to a thirty-three and one-third per cent. solution of the acid. It is antiseptic, and is said not to be poisonous or irritant. It has, therefore, been found adapted in dilute solution for ophthalmological practice.

(13) *Di-iodophenol Sulphonate* (Soziodol). $C_6H_2(HSO_3)I_2$, OH.—Is a white crystalline powder, slightly acid in taste, without odor. Melts at over 200° C., and is decomposed, giving off violet vapors. Scarcely soluble in cold or hot water; not readily soluble in alcohol. The sodium salt is, however, easily soluble in water, alcohol and glycerine. The sodium, potassium, mercury and zinc salts have been therapeutically examined. The salts and the free acid are now extensively used for both external application as a substitute for iodoform, internally, and for insufflations. It contains from fifty-two to fifty-four per cent. of iodine.

(14) *α-Oxynaphthoic Acid.* $C_{10}H_6(OH)CO\,OH$.—Is formed from α-naphthol by methods analogous to those used for the preparation of salicylic acid from phenol. It is an almost white crystalline powder, nearly free from odor, very irritating to the nostrils and of pungent taste. Is insoluble in water, but soluble in alkalies, moderately soluble in alcohol, but less so in chloroform and benzine. Is said to be five times stronger as a disinfectant than salicylic acid and proportionally more fatal to bacteriæ and animal parasites.

This class of phenols, naphthols and derived compounds are at once seen to include the most important of antiseptics and anti-fermentations now known. The distinct germicide character of many of them makes them very important in preventing the spread of these minute and dangerous forms of life. There are, no doubt, many additional compounds that will ultimately be brought into this class of agents. The phenols and naphthols, the aromatic acids, like benzoic, toluic and phthalic, and the mixed phenol acids like salicylic and oxynaphthoic acids, together with a long list of their derivatives, will, in the end, be ranked here.

CLASS III.—OTHER PHENYL DERIVATIVES.

Acetophenone (hypnone),	$C_6H_5.CO.CH_3$
Acetanilide (antifebrine),	$C_6H_5.NH.C_2H_3O$
Brom-acetanilide,	$C_6H_4Br.NH.C_2H_3O$
Benzanilide,	$C_6H_5.NH.C_7H_5O$
Acetyl-amidophenol,	$C_6H_4(OH).NH.C_2H_3O$
Para-acetphenetidine (phenacetine),	$C_6H_4(OC_2H_5).NH.C_2H_3O$
Acetyl-phenylhydrazine (pyrodine),	$C_6H_5.N_2H_2(C_2H_3O)$
Phenylhydrazine-levulinic acid (antithermin),	$C_6H_5.N_2H(CH_3).C_3(CH_2)_2CO\,OH$
Benzoyl sulphinide (saccharin),	$C_6H_4\begin{matrix}CO\\SO_2\end{matrix}NH$

NOTES ON THE CHEMICAL AND THERAPEUTIC CHARACTERS OF COMPOUNDS OF CLASS III.

(1) *Acetophenone* (Hypnone). C_6H_5CO,CH_3.—Is formed by distilling a mixture of calcium benzoate and calcium acetate. Forms large crystalline scales or plates, melting at 20°·5 C., and boiling at 202° C. Sp. gr. 1·032. Has an odor recalling bitter almonds, is not soluble in water or glycerine, but soluble in alcohol, ether and chloroform. Is recommended as a hypnotic and used hypodermically.

(2) *Acetanilide* (Antifebrine). C_6H_5NH,C_2H_3O.—White crystalline scales or needles according to the solvent from which re-crystallized, melting at 120° C., and boiling at 292° C., and sublimable. Is odorless and tasteless. Difficultly soluble in cold water (1 in 60) and hot water (1 in 50), easily soluble in alcohol, ether, chloroform and benzol. Is used as a sedative, a febrifuge and an antipyretic, and in neuralgic and rheumatic affections.

(3) *Brom-acetanilide*. C_6H_4Br,NH,C_2H_3O.—The para compound is made by adding the theoretical amount of bromine to a solution of acetanilide in glacial acetic acid and then purifying by recrystallization out of alcohol. Forms colorless prismatic needles, melting at 165°·4 C. Moderately soluble in alcohol; insoluble in cold water. Is supposed to combine the sedative effects of bromides with the antifebrile effects of acetanilide.

(4) *Benzanilide*. C_6H_5NH,C_7H_5O.—Is made by the action of benzoic acid upon aniline. When recrystallized out of alcohol forms white pearly scales with faint purplish tinge.

Fuses at 163° C. Insoluble in water; soluble in alcohol; difficultly soluble in ether. Said to be analogous in therapeutic character to acetanilide.

(5) *Acetyl-amidophenol.* $C_6H_4(OH),NH,C_2H_3O$. — Is prepared by dissolving amidophenol in hot acetic anhydride and then precipitating out the compound on the addition of water. Forms scales, melting at 201° C. Easily soluble in alcohol and hot water; soluble also in alkalies.

(6) *Para-acetphenetidine* (Phenacetine). $C_6H_4(OC_2H_5),NH,C_2H_3O$.—Forms a white crystalline powder perfectly tasteless and odorless, melting at 135° C. Slightly soluble in water, hot or cold, somewhat more so in glycerine, but freely soluble in alcohol and ether. Is said to be a reliable antipyretic and anti-neuralgic, the dose being half that of antipyrine.

The ortho-acetphenetidine has also been tried and found to be of similar character.

(7) *Acetyl-phenylhydrazine* (Pyrodine). $C_6H_5,N_2H_2(C_2H_3O)$. —Is a white crystalline powder; very sparingly soluble in cold water.

Is a powerful antipyretic, much more so than antipyrine, antifebrine or phenacetine, but also much more toxic than these bodies. Hence must be administered with proper care and observation.

(8) *Phenylhydrazine Levulinic Acid* (Antithermine). $C_6H_5,N_2H(CH_3),C_5(CH_2)_2CO\,OH$.—Is prepared by dissolving phenylhydrazine in dilute acetic acid and then adding a solution of levulinic acid. This causes a yellow precipitate to form, which crystallized from alcohol is gotten in well-formed prismatic crystals. Is said to be a powerful antipyretic.

(9) *Benzoyl Sulphinide* (Saccharin). $C_6H_4\begin{matrix}CO\\SO_2\end{matrix}NH$.— This interesting substitute in sweetening effect for sugar is a white powder of slight odor of oil of bitter almonds, especially noticeable when heated. Slightly soluble in cold water; more readily in boiling water. Reacts acid and has an intensely sweet taste, said to be 280 times as strong as cane sugar. Is readily soluble in alcohol. It passes

through the system unchanged and unabsorbed. It acts, moreover, as an antiseptic and anti-fermentative.

It will be seen on looking at this list that we have among them a number of anilides and derivatives of the same. This observation, of course, points out the possibility of similar character attaching to other derivatives, and the analogous character of derivatives of toluidines on the one hand, and diphenylamine on the other. The study of the chemical character of "saccharin" has already led to discoveries of analogous compounds. I am permitted, by my friend Prof. Remsen, in whose laboratory saccharin was originally discovered, to show this evening three of these derivatives of saccharin, which possess great interest in this connection. They are $C_6H_3Br \begin{cases} CO \\ SO_2 \end{cases} NH$ (brombenzoic sulphinide), $C_6H_3(NO_2) \begin{cases} CO \\ SO_2 \end{cases} NH$ (nitro-benzoic sulphinide), and $C_6H_3(NH_2) \begin{cases} CO \\ SO_2 \end{cases} NH$ (amido-benzoic sulphinide). The first is sweet when tasted by the tip of the tongue and bitter at the base of the tongue; the second is intensely bitter, and the third is intensely sweet. Prof. Remsen has also prepared the chlorine and the fluorine derivatives; the former, like the bromine compound, is both bitter and sweet, the sweet taste predominating; on the other hand, the fluorine compound, strange to say, is sweet like the amido compound.

CLASS IV.—PYRROL AND PYRAZOL DERIVATIVES.

Tetraiodopyrrol (iodol), ...	C_4HI_4N
Diphenyl-methyl-pyrazol, ...	$C_3(C_6H_5)_2(CH_3)HN_2$
Phenyl-dimethyl-pyrazolon (antipyrine), . .	$(C_6H_5)(CH_3)_2C_3HN_2O$

NOTES ON THE CHEMICAL AND THERAPEUTIC CHARACTERS OF GROUP IV.

(1) *Tetraiodopyrrol* (Iodol). C_4HI_4N.—Forms yellowish-gray, fine, light powder. Feels like talc between the fingers. Is almost insoluble in water, but easily soluble in alcohol; soluble also in ether. Is decomposed at the boiling point of alcohol. Tasteless and odorless. It contains

nearly eighty-nine per cent. of iodine. Is about equal to iodoform in antiseptic power, but free from all toxic effects.

(2) *Diphenyl-methyl-pyrazol.* $C_3(C_6H_5)_2(CH_3)HN_2$.—Forms white needles, melting at 150° C. Difficultly soluble in water, ligroïn and ether; easily soluble in alcohol and glacial acetic acid. Is distinguished from antipyrine by its distinctly basic character. Is said to act like antipyrine, and to be used under analogous conditions.

(3) *Phenyl-dimethyl-pyrazolon* (Antipyrine). $(C_6H_5)(CH_3)_2C_3HN_2O$.—Forms a white crystalline powder or in scales, and is very soluble in water. It melts at 113° C. Its most characteristic reactions are with ferric chloride, with which it turns dark red, and with nitrous acid, or nitrites, with which it turns emerald green. It is one of the most successful of antipyretics, and is used as well for its analgesic effects, as a remedy for sea-sickness, etc.

CLASS V.—QUINOLINE DERIVATIVES.

Quinoline,	C_9H_7N
Methyl-tetrahydroquinoline sulphate (M. Kairoline),	$C_9H_{10}N(CH_3).H_2SO_4$
Ethyl-tetrahydroquinoline sulphate (A. Kairoline),	$C_9H_{10}N(C_2H_5).H_2SO_4$
Methyl-tetrahydro-oxyquinoline hydrochlorate (M. Kairine),	$C_9H_{10}NO(CH_3)HCl+H_2O$
Ethyl-tetrahydro-oxyquinoline hydrochlorate (A. Kairine),	$C_9H_{10}NO(C_2H_5)HCl$
Tetrahydroparaquinanisol (thalline),	$C_9H_{10}N(OCH_3)$
Ethyl-tetrahydroparaquinanisol (ethyl-thalline),	$C_9H_9(C_2H_5)N.(OCH_3)$
Methyl-trihydro-oxyquinoline carbonate of sodium (thermifugin),	$C_9H_6(CH_3)N.CO\,ONa$

NOTES ON THE CHEMICAL AND THERAPEUTIC CHARACTERS OF GROUP V.

(1) *Quinoline* (Chinolin). C_9H_7N.—Quinoline is a nitrogenous base found in coal tar and in bone oil. It is, moreover, made synthetically by Skraup's synthesis from aniline, nitrobenzol and glycerine. Several of its salts have been tried in medicine, prominent among which is the tartrate. This is in the form of a white micaceous crystalline powder, of pungent odor and sharp, though not unpleasant taste.

It is an antipyretic although inferior to the others in this group.

(2) *Ethyl and Methyl-tetrahydroquinoline sulphates* (Ethyl and Methyl-Kairoline) $C_9H_{10}N(C_2H_5),H_2SO_4$ and $C_9H_{10}N(CH_3),H_2SO_4$. In both cases, the acid sulphate was used, and their action is similar to but slower than that of kairine salts. They are not now in use.

(3) *Methyl and Ethyl-tetrahydro-oxyquinoline hydrochlorates* (Methyl and Ethyl-Kairine) $C_9H_{10}NO(CH_3)HCl + H_2O$ and $C_9H_{10}NO(C_2H_5)HCl$. The methyl salt is that generally known as "kairine." It is a grayish or yellowish crystalline powder of slight phenol-like odor, and of saline-bitter and somewhat aromatic taste. It is difficultly soluble in cold, more easily in hot water; difficultly soluble in alcohol and glycerine, and nearly insoluble in ether, chloroform and carbon disulphide. It melts at 110° C. It is an antipyretic, but has to be given in repeated large doses, and has been replaced in practice by antipyrine, acetanilide and later compounds.

(3) *Tetrahydroparaquinanisol and its Ethyl Derivative* (Thalline and Ethyl-thalline). $C_9H_{10}N(OCH_3)$.—Thalline itself crystallizes in rhombic crystals fusing at 40° C., of a peculiar, pleasant aromatic odor, and soluble in water, ether and alcohol. The salts that have been used are the tartrate, the tannate and the sulphate. The latter, now known as the commercial "thalline," is a white crystalline powder, which fuses at 110° C., and is moderately soluble in water, but difficultly in cold alcohol. A drop of ferric chloride solution produces a beautiful dark-green color, which, in the course of a day, becomes red and ultimately yellow. The reaction will show in extremely dilute solutions. The name is due to this reaction, which is produced by a variety of oxidizing agents. It is a very efficient and rapid antipyretic, and is said to be best administered in repeated small doses, so as to produce cumulative effect. Is particularly recommended for typhoid fevers.

(4) *Methyl-trihydro-oxyquinoline carbonate of sodium* (thermifugin). $C_9H_8(CH_3)N,CO\,ONa$.—The acid was recently discovered by Nencki, of Basel. Its sodium salt, the "thermi-

fugin," has been found by Dr. Demme, of Berne, to be an interesting antipyretic. It is said to combine the three effects of reducing temperature, of retarding the pulse, and of increasing the blood pressure. The free acid forms beautiful crystals, which are but little soluble in water or alcohol, and melt at 265° C. The sodium salt is faintly yellowish-white, lustrous and dissolves to form a brown solution.

With this compound is completed the last or fifth group of compounds selected for mention. These five groups, however, do not cover the whole ground of synthetic compounds introduced into medicine in recent years. Liebermann showed, in 1878, that a reduction product of chrysophanic acid $C_{15}H_{10}O_4$, to which he gave the name of chrysarobin, and the formula $C_{20}H_{26}O_7$ was the active principle in Goa powder. Now, as chrysophanic acid is the alizarine of methyl-anthracene, Liebermann determined to investigate the reduction products, or leuco-bodies, as they are termed, of commercial alizarine and purpurine. He has thus discovered recently a series of compounds, to which he gives the names of "*anthrarobins.*" The large sample shown is commercial anthrarobin from artificial alizarine. It is a yellowish-white powder permanent in air, insoluble in water and dilute acids, but readily soluble with brown-yellow color in dilute solutions of the alkalies and alkaline earths, the solutions in contact with oxygen passing through green and blue, finally into alizarine-violet. Anthrarobin is used already in many cases of skin diseases. It is said to be intermediate in character between chrysarobin and pyrogallol.

The list of miscellaneous synthetic preparations might be expanded at great length, but my object was not so much to make an enumeration as to classify the more prominent of these compounds.

If the question be asked what limits can be set to the possibilities in the direction of synthetic manufacture, I would remind the inquirer that when W. H. Perkin discovered mauve, the first of the aniline dyes, in 1856, no one could have predicted the enormous development of the coal-tar color industry. So now, it is impossible for us to foresee

how extensive or how rapid will be the development of the manufacture of synthetic remedies. We have yet to accomplish the synthesis of most of the important alkaloids, and it is likely that hundreds, if not thousands, of analogous working compounds will be obtained before all of them are thoroughly investigated.

In conclusion, I must acknowledge my indebtedness to E. Merck, of Darmstadt and New York, to Messrs. Lehn & Finck, W. H. Shieffelin & Co., Roessler & Hasslacher, John Campbell & Co., Eimer & Amend, Lutz & Movius, Wm. Pickhardt & Kuttroff, of New York, and to Drs. S. C. Hooker and H. W. Jayne and Messrs. Bullock & Crenshaw, of this city, for favors in the presentation or loan of specimens for the illustration of this lecture.

UNIVERSITY OF PENNSYLVANIA,
PHILADELPHIA, January, 1889.

PERMEABILITY OF CEMENTS.

BY LEWIS M. HAUPT.

The desirability of using concrete of cement for lining aqueducts, cisterns, tanks, and for the construction of submarine tunnels, dams, and other works, involves the question of the permeability of the materials, especially when the conduits are subjected to hydrostatic pressure; yet the literature of the subject appears to be very meagre. Doubtless many facts exist of value to engineers on this important subject, but they do not appear to be available to the profession, and the recent discussion upon the possibility of lining the new Washington aqueduct with concrete instead of a brick ring with dry back filling has failed to develop any material facts, but reveals a remarkable difference of opinion amongst those taking part in that discussion. The accompanying paper may be of some service in this direction, and is presented with the view of eliciting further facts from engineers or others who may be interested in the subject. L. M. H.

NOTE ON THE PERMEABILITY OF MORTARS OF PORTLAND CEMENT, AND THEIR DECOMPOSITION UNDER THE ACTION OF THE SEA.

By MM. LÉON DURAND CLAYE, Engineer in Chief of Bridges and Roads, and PAUL DEBRAY, Assistant Engineer.

[Translated from the *Annales des Ponts et Chausées*, May, 1888, by L. M. Haupt, Professor of Civil Engineering, University of Pennsylvania, for the JOURNAL OF THE FRANKLIN INSTITUTE.]

Until the present time it was generally admitted that mortars, composed of Portland cement, if not absolutely unalterable by sea water, at least were affected only by its destructive action after long exposure, and then only to a small extent.

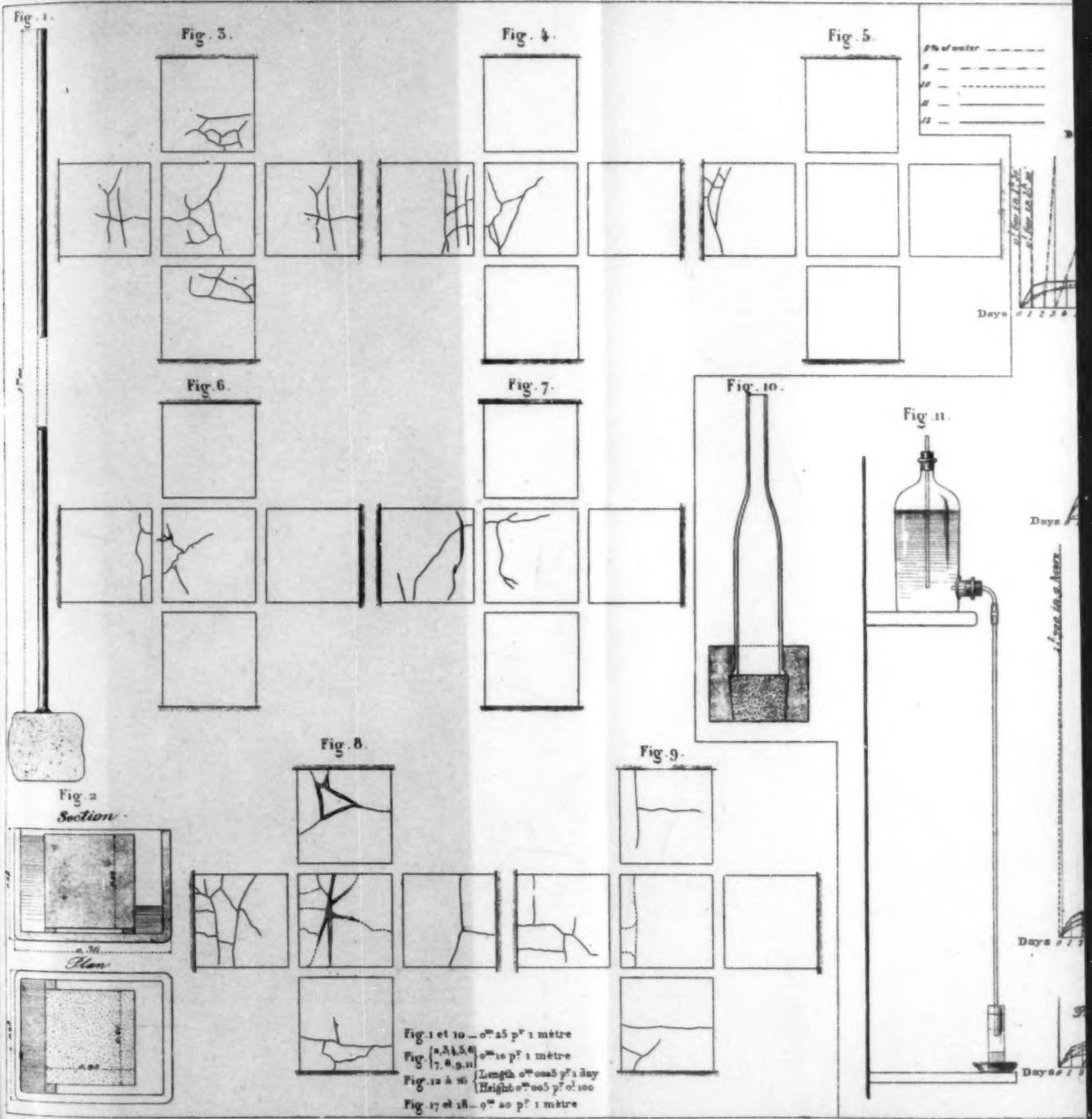
Several recent accidents have unfortunately impaired general confidence in the use of Portland cements, and show that, to prevent unfortunate contingencies in maritime works, it is *always* necessary to observe the most minute precautions in the mixing of mortars, as well from Portland cement as from hydraulic limes, for use in masonry.

Quay walls, laid in solid mortar, called béton, composed of about 200 kilograms (440 pounds) of Portland cement to each cubic metre of sand, and from 150 to 200 kilograms of water, laid in layers and surmounted by ashlar masonry, were disintegrated by the action of sea water in a very short time, *i. e.*, in less than a year for certain parts of the work.

It has been observed also that the masonry of wet docks gives evidence of movement within the few months succeeding the letting in of the water, and in a short time shows numerous fissures, even where there has been used a Portland cement mortar containing 300 kilograms (660 pounds) of cement per cubic metre of sand for the hearting and 400 kilograms for the facing.

At the request of the Commission on Tests of Cements, we proceeded to analyze numerous specimens collected with care by resident engineers and to seek to explain, by the aid

PERMEABILTY OF MORTARS OF PORTLAND CEMENT. ACT



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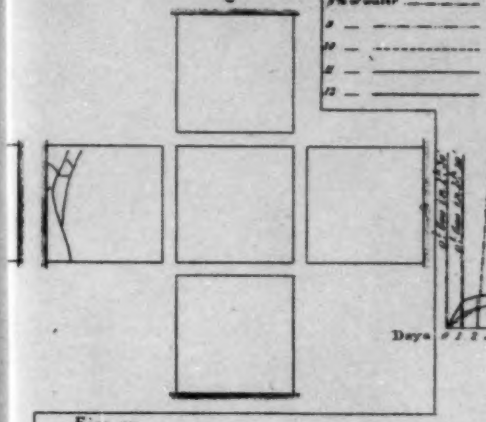

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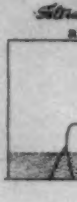

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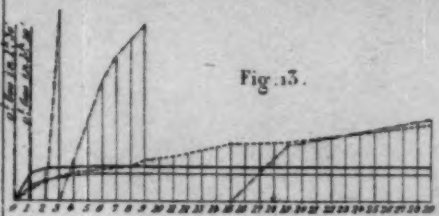


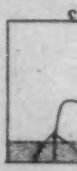


Fig. 10.

Fig. 11.

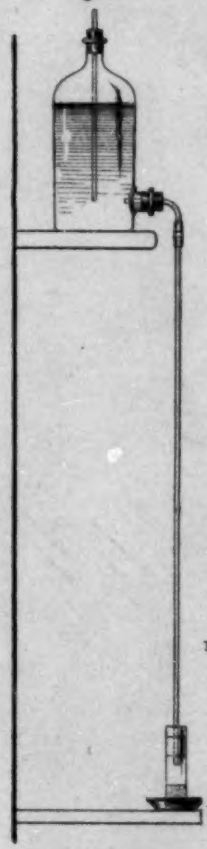
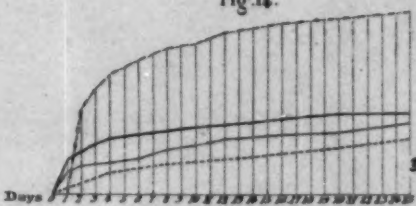


Fig. 14.



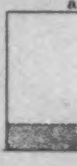
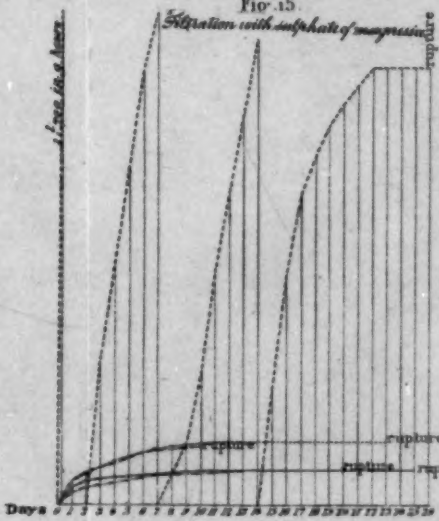


Fig. 15.



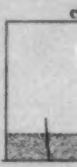


Fig. 16.

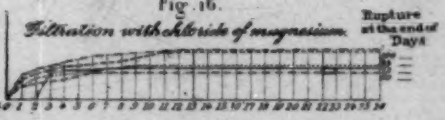


Fig. 17

Filtration with sulphate of magnesia

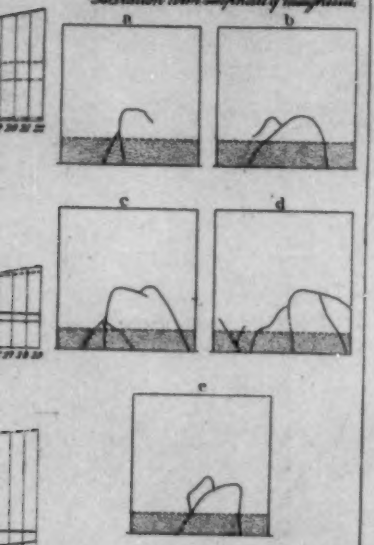
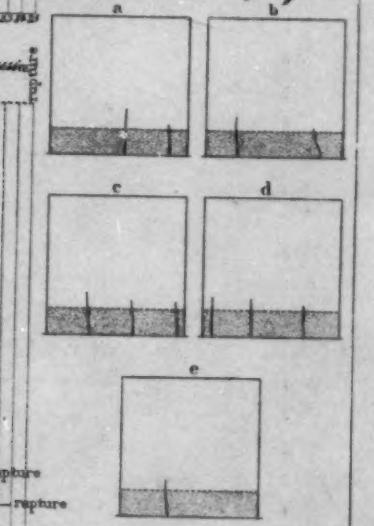


Fig. 18

Filtration with chloride of magnesium



Conventions

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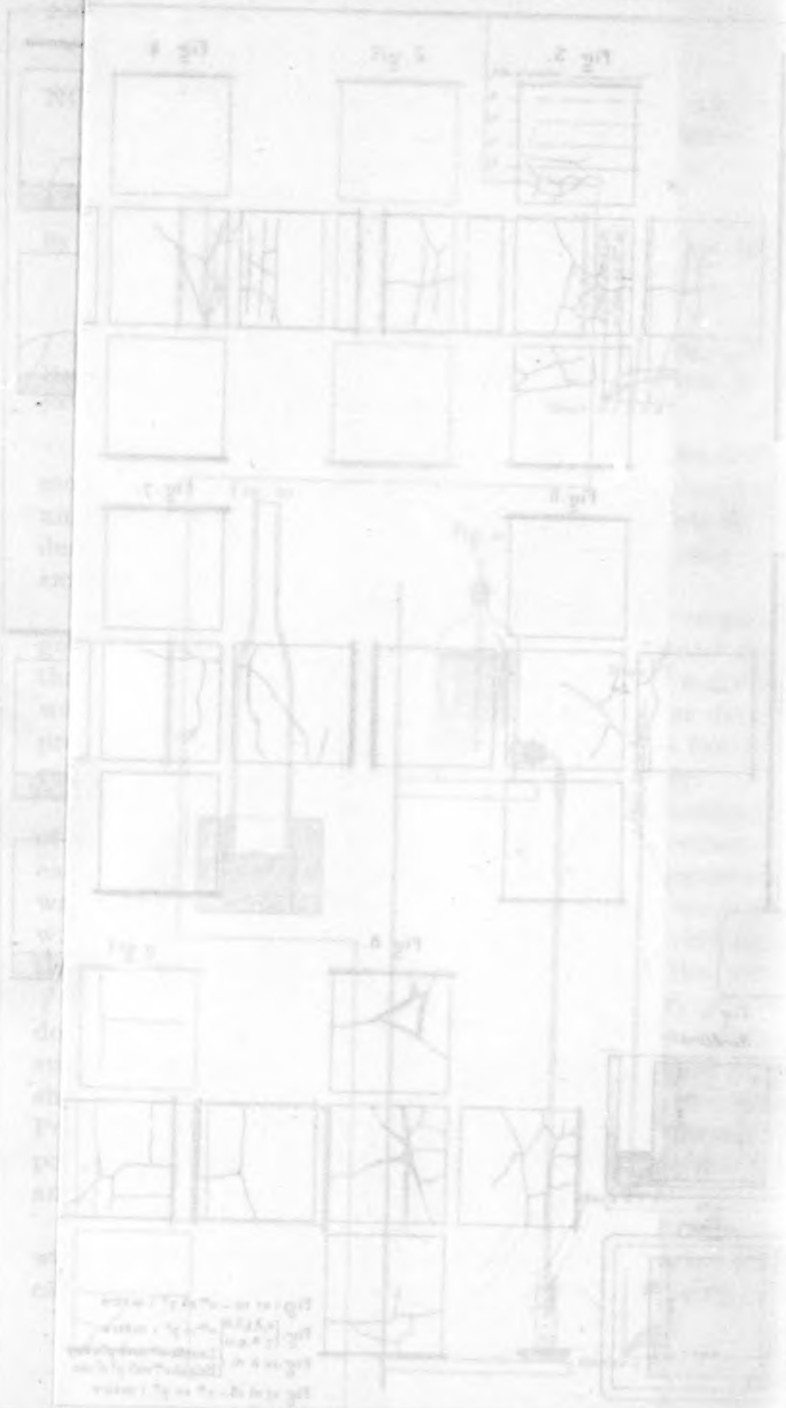

of laboratory experiments, the accidents with which we were impressed.

The present note gives the result of our studies and researches.

(1) ANALYSIS OF THE SPECIMENS.

The samples of "béton de sable," fifteen of which were sent us, were not taken from the same cross-section, nor even from the same part of the quay wall; they are not then justly comparable. Nevertheless, profiting by the suggestions sent us therewith, we have presumed to place them in the same hypothetical section, classifying them from the top to the bottom of the section.

We state hereafter in a table, where the samples are classed in this order, the leading results of our analysis, in percentages of lime, magnesia and sulphuric acid. Accepting the suggestions given us by a member of the Commission on Cement, we give also the weight of magnesia to the sum of the weights of the lime and magnesia. This statement may be regarded as characteristic of the condition of the specimens.

Name of Sample.	Per Cent. of Magnesia.	Per Cent. of Lime.	Relative Weight of Magnesia to the Total Weight of Lime and Magnesia.	Quantity of Sulphuric Acid.
M,	0·25	13·05	0·02	0·05
P,	0·20	13·00	0·01	0·10
L,	0·25	11·40	0·02	0·50
H,	0·30	10·35	0·03	0·05
G,	0·35	9·75	0·03	0·05
E,	1·60	8·50	0·16	0·30
F,	0·10	10·20	0·01	0·45
D,	0·10	10·10	0·01	0·40
N,	0·45	11·45	0·04	0·60
K1,	2·90	5·80	0·33	0·60
K2,	3·90	4·70	0·45	0·40
K3,	0·35	11·90	0·03	0·95
B,	0·10	9·95	0·01	0·35
C,	0·25	11·35	0·02	0·40
A,	2·70	6·15	0·30	0·60

An inspection of this table shows that the proportion of magnesia and the amount of sulphuric acid are very variable from one specimen to another, which can only be due to the action of the sea water after placing the béton in the water

of the basin. It is also observed that the samples showing the largest amounts of magnesia or sulphuric acid correspond to those parts of the quay walls which suffered most damage.

We give also below the analysis of mortars taken from the masonry joints of the wet-dock, from places where the cracks appeared largest and most alarming.

Name.		Per Cent of Magnesia.	Per Cent. of Lime.	Relative Weight.	Sulphuric Acid.
Mortars from under the banket of the graving dock.	1	3·50	7·65	0·31	1·10
	2	2·70	8·45	0·24	0·85
	3	1·65	8·05	0·17	1·20
Mortars from the curb of the graving dock.	4	4·50	6·85	0·39	1·55
	5	7·80	10·20	0·43	0·40
	6	4·05	7·40	0·35	1·08

The results of this analysis show distinctly that in the second case as in the first, mortars of Portland cement have been materially changed by the action of sea water.

(2) EXPERIMENTS ON THE PERMEABILITY OF MORTARS.

In perfectly sound specimens, obtained from the highest parts of works where the basins had not yet been filled with water, we have invariably found that béton of sand and mortars were not only very porous, but also very permeable.

We call attention to the fact that it is necessary to make a marked distinction between porosity and permeability. Porosity is the faculty which motars exposed to the air have of absorbing a certain quanity of water whenever they are immersed in a vessel and left there sufficiently long. It is an easy matter to determine the measure of the porosity. For this purpose take any assumed quantity, which is weighed, either immediately or after drying, in a moderate temperature. This gives a known weight (P). The same specimen is again weighed after saturation, giving a greater weight P'. Hence, the porosity is given by the ratio

$$\frac{P' - P}{P}$$

which represents the proportional increase of weight of the

mortar resulting from the absorption of a certain quantity of water which has penetrated the pores and filled the voids occupied by the air.

Permeability is the faculty whereby blocks of mortar submitted to the action of a head of water on one of their faces, transmits through their mass a certain quantity of the water. Other things being equal, the permeability would be measured by the amount of water which passes through in a given time.

It is a very difficult matter, however, to put different blocks of mortar under *equal* conditions, so that the volume of water passing through them may give a *measure* of their relative permeability.

We will explain, subsequently, the apparatus we have prepared to measure the permeability of mortars of different compositions, but without being able to reach very satisfactory results.

Although it is not possible to measure with mathematical accuracy the permeability of specimens of mortars taken from masonry, it is always easy to learn whether or not they are permeable.

It is sufficient to seal upon a fragment of the mortar, whatever its form may be, by means of wax, a glass tube of about a meter in height, and to fill this tube with water. (*Fig. 1*, pl. 6.)

When the mortars are very permeable, the water in the glass tube is seen to fall quite rapidly, and a condensation more or less profuse takes place on the mortar. The experiment may be repeated, as soon as desired, by refilling the glass with water.

The glass tube may also be connected with a "Mariotte" flask, thus maintaining a constant head. But in either case, the irregularity in the form of the specimen under treatment, and the difficulty of noting the influence of this irregularity on the rate of filtration, prevents the giving of a coëfficient of precise value for the permeability of experimental mortars.

Having recognized the permeability of the béton and mortar which we have submitted as susceptible to decom-

position under the action of sea water, we have thought to reproduce the phenomena under investigation by substituting for sea water some solutions of the salts of magnesia.

In a first experiment we have submitted a sound block of "béton de sable" to the action of a six per cent. solution of sulphate of magnesia, applied upon one of the side faces, under a mean pressure of ten centimetres in height. For this purpose, we placed this block in an earthen vessel, as shown in *Fig. 2*. By means of a packing of neat cement we formed, on the left of the block, a sort of reservoir, which was filled each day with the above solution. The water filtered through the block and collected in the other part of the vessel, from which it was withdrawn periodically by a siphon.

From the date of the placing of the specimen it was ascertained that there was produced an expansion in the mass of the block; about the sixteenth day there was visible on the upper face the first fissure three to four centimetres long and perpendicular to the bearings.

The next day another fissure was observed, at right angles to the first, to which it was connected by two light tendrils. This cross fissure soon became of great importance, prolonging itself with accessory cracks to the right and left of the block. (*Fig. 3*, pl. 6.)

At the same time, in consequence of the transverse expansion of the block, the vessel in which it was bound burst on both sides only twenty days after the beginning of the experiment. We were obliged then to cease the filtering of the water, but, nevertheless, the block continued to expand and to crack until we broke it to examine the changes which had taken place in the interior. It was found that the centre was reduced to a white pulp without consistency, precisely like that shown in a greater or lesser degree in the damaged works.

We have recently renewed this experiment with other blocks of "béton de sable" obtained also from the works, mixed with different French, English and Belgian cements. We have treated these blocks as indicated below, with these differences, that the earthen vessel was replaced by one of

galvanized iron and that the packing strips to enclose the reservoir on the side were made of modelling wax in place of cement.

We have also reduced the proportion of the solution of sulphate of magnesia to six parts per 1,000 instead of per 100 to approximate the quantity of the salt to that found in sea water, and not to exaggerate the decomposition of the blocks as we had occasion to do in the first experiments, with the desire to reach an appreciable result with little delay, *which we dared not hope for at first.*

We have obtained the same results with the different blocks under trial, as that was the production of the cements employed in this manufacture; only the phenomena of disintegration and of decomposition are produced in different places with more or less rapidity, according to the amount of filtration. We give also sketches of the results of these experiments in *Figs. 4* to *9*, pl. 6.

We have not made direct tests of decomposition under the action of magnesium solutions, on the fragments of cement mortars of 300 to 400 kilograms, which we have received. They were of irregular form, and not well adapted to experimentation, having been at some time or other submitted, more or less, to the action of the sea.

But we have sought to mix in the laboratory some gauges of mortar well adapted to the filtration tests. Without having yet found a system to satisfy us, we have tried different combinations, which it is perhaps not without interest to explain in detail, to give to experimenters, who may wish to develop the subject further, the useless experiments and discouraging deceptions.

First, then, we tried a mixture in truncated conical moulds of mortar, four centimetres high by five diameter of larger base, and forty-five millimetres for diameter of smaller base. Above these disks, on the side of the larger base, was placed a glass tube, the joint being enlarged, as shown in *Fig. 10*, and enclosed in a mass of pure cement. We made four series of three disks, with the following proportion:

(*a*) 200	kilos of cement	and	200	kilos of water	to 1	cubic metre of	fine sand.
(*b*) 200	"	"	150	"	1	"	"
(*c*) 350	"	"	200	"	1	"	"
(*d*) 350	"	"	150	"	1	"	"

In each series we first submitted the disks to filtration with clear water, then with water containing six per cent. of sulphate of magnesia, followed by water containing thirty per cent. of the same salt.

The mortars were very permeable, and we had only to fill the tubes to obtain abundant filtrations. It was not necessary to give a pressure greater than it would have been easy to produce, by splicing the glass tubes by rubber bands over their ends.

These experiments on filtrations were continued about twenty-five days. It was established that in general the disks which had been submitted to water charged with sulphate of magnesia were ruptured to so much greater extent, as the proportion of cement in the mortar was increased; as the proportion of water was reduced, or as the water used for filtering was enriched by the salt.

We have analyzed these disks, and show, by the analyses (see the annexed table):

(1) That filtration with pure water had removed a certain proportion of the lime existing in the mortars and coming from the cements.

(2) That under the action of water charged with sulphate of magnesia, part of the lime contained in the mortars disappear, whilst the proportion of magnesium and of sulphuric acid is found to increase.

We have consequently abandoned this method, thinking that it was preferable not to introduce at the side of the mortars a band of cement, which being submitted to natural agencies, affects the results sought.

We have sought then to obtain in tubes of glass of a convenient diameter (three to four centimetres), some disks of mortar adhering directly without the interposition of any foreign substance.

We procured some ends of strong glass tubes three to four centimetres in diameter and ·12 metres long, and filled

their extremities with disks of cement. (We omit the description of the method of filling the tubes.)

After a few days the disks thus formed are sufficiently adherent to be submitted to a charge of one metre of water, by the apparatus represented in *Fig. 11*, pl. 6.

In our experience each tube was sealed at its upper end by a strong rubber cork, with a round hole for a glass pipe of about one metre in height. Above, on a shelf, a series of Mariotte vases were arranged, containing water from the Seine, or solutions of magnesia. The joints were made by rubber tubing, and thus the cakes were submitted to a uniform pressure, and the quantity of water filtering through was measured either by collecting it, or by noting the lowering of the level in the previously gauged Mariotte vases.

Our experiments have demonstrated that although the filtration was very rapid at first, it diminished rapidly in importance, and in a short time it became, if not absolutely nil, at least very weak. But at the same time we have shown that the tube enclosing the disks cracks or even breaks away from them in consequence of the expansion of the mass. We show (Pl. 6, *Figs. 12*, *13* and *14*) the results of experiments made on three series of mortar tablets, made in the proportion of one part of cement to four of sand, by weight, and mixed with water varying from eight, nine, ten, eleven to twelve per cent. of the sum of the weights of cement and sand. The law of decrease of filtration is seen very well, as also the influence which the proportion of water used in tempering has upon the rate.

In the first series, or when the water was nine per cent. of the weight, the filtrations were the least abundant. Mortar made with seven per cent. was very permeable, as is shown on the diagram. That of ten per cent. was more permeable than that of nine or eight per cent., whilst that of eleven per cent. was still greater than that of ten.

In the second series, when the proportion of water was eleven per cent., there was the least filtration. The eight per cent. mortar was so very porous that it was not possible to draw the corresponding curve.

In the third series ten per cent. give the minimum. It

was not possible to represent the filtration curve for eight per cent.

There seems to result from these experiments that for each proportion of mortar and of sand a certain quantity of water corresponds to the maximum density and minimum permeability of the mortars. This phenomenon explains itself naturally if we observe that at the instant of making the disks the grains of sand and cement are in the same state.

Now, we know that sand when quite wet occupies a larger volume than when dry; and that on the other hand it shows a considerable settling when it is covered with water.

The grains of cement are in the same condition, but when the quantity of water is considerable and the material is worked as in the making of mortars, they do not remain in suspension but are combined, at the instant of mixing, at relatively great distances from each other.

We have also studied the comparative action of solutions of sulphate of magnesia and chloride of magnesium in the proportion of six per cent. in two series of five disks mixed with one part of cement to four of sand and ten per cent. of water, mixed in pairs to eliminate, so far as possible, all other influences than those due to the salts employed.

Pl. 6, *Figs. 15* and *16*, show the curves of filtration of these disks, and *Fig. 17* shows one part and *Fig. 18* another, of the several faces surrounding the disks of mortar, reduced in proportion of five to one. The specimens submitted to the action of sulphate were broken from the tenth to the twenty-sixth day of filtration, whilst those submitted to the chloride resisted at least sixty days. It is noticeable also that the cracks in the first case are more numerous and deeper than in the second, indicating a more energetic action. We should add, however, that all the disks preserved their compactness, and that their swelling did not seem to have affected their resistance.

Chemical analysis proves that the disks submitted to the action of the sulphate contained from ·75 to ·80 per cent. of sulphuric acid, from which we conclude that a double decomposition has taken place between the salts of lime

and the sulphate of magnesia, as pointed out long since by Vicat; a part of the sulphate of lime forms and remains in the mass of the mortar.

It is to the production, in masses of mortar of perceptible quantities of sulphate of lime, that we are led to attribute the phenomena of the dislocation of masonry of Portland cement mortar submitted to the action of the sea.

Our analyses appear to us to show, as an indisputable fact, that the sulphate of lime produced by the action of the sea on mortars, is not entirely drawn out by the water which circulates in the masonry, and which plays a very important part in the disintegration of this masonry.

Whilst the magnesia appears to partake of the nature of thin cream without consistency, it is unable to exercise any mechanical action on the masonry; whereas the sulphate of lime solidifies more or less completely in crystals of such a nature as to develop considerable molecular activity.

Paris, 16 January, 1888.

NOTE.—Disks of cement mortar.

The first series were made in the proportion of 200 kilograms of cement and 200 liters of water to each cubic metre of sand; the first disk kept for reference was exposed to the air, the others were submitted to the action of pure water, or to a solution of sulphate of magnesia containing at first six per cent. and second thirty per cent. of the salt filtered through the mass.

Proportion, ... { 1 cubic meter of sand, 200 kilogrammes of cement, 200 litres of water.

FIRST SERIES.	DISKS.			
	Dried in Air.	*Traversed by*		
		Pure Water.	Water at 6 Per Cent.	Water at 30 Per Cent.
Insoluble residue, ...	82·35	80·55	75·40	72·90
Alumina and peroxide of iron, ...	1·65	1·65	1·60	1·35
Lime, ...	10·75	9·35	8·35	8·80
Magnesia, ...	0·13	0·20	2·30	2·10
Sulphuric acid, ...	0·05	0·15	2·65	4·25
Loss by heat, ...	4·80	8·00	9·90	10·40
Error, ...	+ 0·25	+ 0·10	— 0·20	10·40
TOTAL, ...	100·00	100·00	100·00	100·00

(2) The disks of the second series were made in the proportion of 200 kilogrammes of cement and 150 litres of water to one cubic meter of sand; these were submitted to the same tests as the first.

Proportion, ... { 1 cubic meter of sand, 200 kilogrammes of cement, 150 litres of water.

Second Series.	Disks.			
	Dried in Air.	*Traversed by* Pure Water	Water at 6 Per Cent.	Water at 30 Per Cent.
Insoluble residue,	82·35	78·40	77·00	74·25
Alumina and peroxide of iron,	1·50	1·80	1·80	1·75
Lime,	10·70	9·55	8·35	8·50
Magnesia,	0·10	0·10	2·00	2·20
Sulphuric acid,	0·10	0·30	2·00	2·60
Loss by heat,	4·90	9·80	8·80	10·75
Error,	+ 0·35	+ 0·05	+ 0·05	— 0·05
Total,	100·00	100·00	100·00	100·00

(3) This third series of disks was made in the proportion of 360 kilogrammes of cement and 200 litres of water to one cubic meter of sand.

Proportion, ... { 1 cubic meter of sand, 350 kilogrammes of cement, 200 litres of water.

Third Series.	Disks.			
	Dried in Air.	*Traversed by* Pure Water.	Water at 6 Per Cent.	Water at 30 Per Cent.
Insoluble residue,	77·00	73·60	67·55	67·65
Alumina and peroxide of iron,	2·50	2·50	2·25	2·65
Lime,	14·25	12·55	11·35	11·35
Magnesia,	0·10	0·05	2·70	2·30
Sulphuric acid,	0·10	0·30	4·40	4·95
Loss by heat,	6·00	10·95	11·90	11·10
Error,	+ 0·05	+ 0·05	— 0·15	11·10
Total,	100·00	100·00	100·00	100·00

(4) The disks of the fourth series were made in the proportion of 350 kilogrammes of cement and 150 litres of water for every cubic meter of sand

Proportion, ... { 1 cubic meter of sand, 350 kilogrammes of cement, 150 litres of water.

Fourth Series.	Disks.			
	Dried in Air.	*Traversed by*		
		Pure Water.	Water at 6 Per Cent.	Water at 30 Per Cent.
Insoluble residue, ...	77·05	71·55	68·10	67·70
Alumina and peroxide of iron, ...	2·65	2·45	2·20	2·60
Lime, ...	14·70	12·25	11·15	11·85
Magnesia, ...	0·10	0·15	2·80	2·35
Sulphuric acid, ...	0·10	0·15	4·05	4·50
Loss by heat, ...	5·25	13·50	11·85	11·10
Error, ...	+ 0·25	— 0·05	— 0·15	— 0·10
Total, ...	100·00	100·00	100·00	100·00

ADDENDA BY L. M. HAUPT.

The writer recently had an interview on this subject with Mr. Jno. C. Goodridge, Jr., whose long experience with cements makes him an authority, and learned that in using cement for water tanks it was found that when filled the first time they leaked badly and the water soon escaped, but each time they were refilled the leakage was less, and that in about a week, or after six or seven fillings, they became practically tight and remained so.

In his investigations upon high walls or dams to resist the pressure of water, Major J. B. Francis made some experiments to determine "whether the pressure of water can be communicated through the capillary channels in the mortar. The apparatus consisted of an iron filter connected with pipes and pressure gauges, by means of which a plug of Portland cement, mortar in the proportion of one part of cement to two of sharp pit sand, was subjected to pressure. "The experiment consisted in noting the pressures at the several gauges at the beginning and end of periods, which gave sufficient time for them to become established." * * Unfortunately the case was not a sound casting and there were minute leaks, which materially modified the results.

For full description reference is made to the *Transactions Am. Soc. of Civil Engineers*, October, 1888.

PROCEEDINGS

OF THE

CHEMICAL SECTION,

OF THE

FRANKLIN INSTITUTE.

[*Stated Meeting, held at the* INSTITUTE, *Tuesday, February 19, 1889.*]

HALL OF THE FRANKLIN INSTITUTE.
PHILADELPHIA, February 19, 1889.

Dr. SAMUEL C. HOOKER, Vice-President, in the Chair.

Members present: Dr. L. B. Hall, Dr. H. W. Jayne, Dr. Wm. H. Wahl, Dr. E. H. Keiser, Dr. H. F. Keller, Prof. Henry Trimble, Prof. E. F. Smith, Messrs. W. L. Rowland, F. C. Lewin, A. T. Eastwick, Marshall R. Pugh, T. C. Palmer, Dr. W. C. Day, and a number of visitors.

An abstract of a letter from Prof. Ira Remsen, editor of *The American Chemical Journal*, was read. The letter requested first publication of papers read before the Section.

The Committee on By-Laws, Mr. T. C. Palmer, Chairman, submitted a report, which was read and approved. Accompanying the report was a copy of the revised By-Laws, which was read; a few changes were made and, in order to give time for the full consideration of the By-Laws, they were laid over until the next meeting for final action, the Secretary being instructed to have them printed and to send a copy to each member of the Section.

A report from the Treasurer was read and, in connection therewith, it was recommended that certain delinquent members should be notified that unless arrears be made good their names would be dropped from the list of members; it was also recommended that such notification should be given in all similar cases occurring in future.

The following gentlemen were elected members of the Section: Dr. T. R. Wolf, Newark, Del.; Mr. C. J. Semper, 505 South Forty-first Street, Philadelphia; Mr. S. Lloyd Wiegand, 146 South Sixth Street, Philadelphia; Prof. Edgar F. Smith, Ph.D., University of Pennsylvania; Mr. Marshall R. Pugh, University of Pennsylvania.

Mr. F. Lynwood Garrison was nominated for membership in the Section.

The motion that the annual dues be increased from one dollar to two dollars, the initiation fee remaining one dollar, as heretofore, was carried.

The resignation of Mr. Robert Frazer was accepted.

Mr. T. C. Palmer's paper, "On the Ash of *Tillandsia Usneoides*," a copy

of which was already in the hands of all the members, was read by title. The author requested that those who might be able to contribute information or give reference to papers on this subject would kindly do so, as he is still occupied with the investigation of the way in which this plant obtains its mineral nourishment.

Dr. H. F. Keller then read a paper "On Diacetyl and Some of its Derivatives;" which has been referred for publication.

Diacetyl was first produced by heating ketipic acid, which splits up into carbon dioxide and a yellow volatile liquid which proved to be diacetyl. The facts upon which the structure of this substance is based were considered, as well as the methods of preparation, composition and properties of a number of its derivatives.

Dr. Hooker showed a specimen of benzil, the compound in the aromatic series which corresponds to diacetyl.

Dr. Wahl gave a brief account of some interesting experiments, upon which he is now engaged, in connection with the electrolysis of hydrochloric acid. In electro-plating with platinum and iridium, a number of difficulties present themselves; the solution of metal constantly varies in strength, owing to the fact that the metal is dissolved only in insignificant quantity at the anode, so that the metallic strength of the plating solution is constantly being weakened, requiring frequent additions to be made to the bath. Another difficulty is that the deposit is spongy, black and non-adherent in character, rather than reguline and bright. The first difficulty has been overcome by Dr. Wahl, and he is now working with special reference to the second, with encouraging prospects. Dr. Wahl expects to bring before the Section, in the near future, a paper which will consider in detail his experiments and their results. Professor Smith described a method of determining platinum electrolytically by depositing the platinum from the compound, K_2PtCl_6, on a platinum dish (previously plated with copper), by means of a low current applied for five or six hours; the presence of sulphuric acid is advisable. No platinum could be detected in the liquid after the action. Dr. Wahl then exhibited some specimens of his platinum and iridium plating, which were inspected with much interest by the members.

The Secretary exhibited a specimen of highly bituminous coal from a new source in Alaska.

Adjourned.

WM. C. DAY, *Secretary.*

ABSTRACTS.

CAYOTA, A NEW TANNIN. M. Villon (*L'Ind. Text.* and *Textile Colorist*, **11,** 8).—This reddish-brown bark comes from the southern part of Mexico, where it is used for tanning thick sole-leather, to which it is said to impart "strong consistency and great solidity." It is easily powdered, has a resinous odor, and according to Mr. Ebertz, of Berlin, contains twenty-two to thirty per cent. of tannin. The pure tannin, separated by the author, consists of yellow scales, which dissolve in fifteen parts of their weight of cold water, and

in all other solvents for tannin. It colors the salts of iron a fine black, whose intensity is variable according to whether the decoction or extract of the bark is obtained in the cold, or by boiling under pressure or in the presence of oxydizing agents. Its molecular weight is equal to that of the tannin from oak bark. The bark or extract is said to be superior to Quebracho on account of the absence of resin, and to give to silk the suppleness of sumac.

H. T.

ON THE DETECTION OF CAUSTIC ALKALI IN THE PRESENCE OF ALKALINE CARBONATES. L. Dobbin (*Jour. Soc. Chem. Ind.*, December 31, 1888, pp. 829–830).—This method depends on the coloration of dilute solutions of potassium iodide in mercuric chloride, to which ammonium chloride has been added. This reagent gives no coloration or precipitate with sodium or potassium carbonate, but forms a delicate test for caustic alkali, a yellow coloration being produced as soon as a sufficient quantity has been added to change the whole of the ammonium chloride present into potassium salt and free ammonia. By using a reagent containing a very small proportion of ammonium chloride the test is extremely delicate. The quantity of caustic alkali is estimated by color comparison.

M. R. P.

ON SOME ABNORMAL SAMPLES OF BUTTER. A. H. Allen (*Analyst*, January, 1889).—Professor Stein, official analyst to the Danish government, having been led to doubt how far the limits generally adopted by public analysts in the examination of butter were to be relied on, an investigation was ordered by the Royal Agricultural Society, and the author invited to take a part in it. Average butter fat takes by the Reichert-Wollery process 29·2 cc. $\frac{n}{10}$ alkali, whereas butter from one of the farms inspected, which had been so closely watched as to render adulteration impossible, took but 24·7 cc., and that from another but 22·3 cc. $\frac{n}{10}$ alkali. Although these butters are exceptional, yet they were produced from the milk of a large number of cows, so it cannot be said that such butter may not be met in practice. Nilson, of Stockholm, found the volatile acids to vary materially with the time since calving. The author also discusses the detection of vegetable oils. In conclusion he recommends that a committee of the Society of Public Analysts receive and tabulate results of analysis, and devise, if possible, some method of examining butter less dependent on the natural variations in its composition, than the methods at present in use.

M. R. P.

ARTIFICIAL COFFEE. A. Stutzer (*Zeitschr. für Angewandte Chemie*, 1888, p. 699).—The author calls attention to the manufacture of artificial coffee and of machines for that purpose as carried on by certain firms in Cologne. The following analytical results of the artificial product were obtained by O. Reitmair:

	Per Cent.
Moisture,	8·30
Extract soluble in hot water,	34·34
Insoluble organic constituents,	56·36
Inorganic material,	1·10

A microscopic investigation showed that the bulk of the artificial coffee

consists of burnt flour or meal. According to Reitmair, the artificial beans (which are well formed) may be distinguished from the genuine by the fact that the former immediately sink when immersed in ether, while the genuine, on account of the fat contents, float, in great part, on the surface. Furthermore, genuine coffee beans are much more rapidly decolorized by the action of hot, strong oxidizing agents (such as aqua regia or $HCl + KClO_3$) than the artificial. In detecting adulteration of coffee by the artificial article both of these methods of testing should be carried out as preliminary measures. W. C. D.

SALICYLIC ACID FOR PRESERVING EGGS. Lambert (*Arch. de Pharmacie*, 1888, 440).—A solution of salicylic acid is not to be recommended for keeping eggs in preference to lime-water. The acid diffuses through the shell and may be readily detected on the white of the egg. S. C. H.

A GERMAN patent (D. R. P. 45,857) has been granted to A. Doutrelpont, for a process of preparing a new explosive, "Petragit," from molasses. It is an oily nitro-product, and is said to have three times the power of nitro-glycerine. S. C. H.

THE ANALYTICAL EXAMINATION OF WATER FOR TECHNICAL PURPOSES. Alfred H. Allen (*Journ. Soc. Chem. Ind.*, **7**, 795).—The results given by the soap test when water contains considerable quantities of magnesium compounds in addition to lime salts are very misleading. A water, containing both lime and magnesia, does not destroy so much soap as the same amounts of lime and magnesia would do separately. The author speaks strongly against further employment of the soap test, unless some means can be found of counteracting the disturbing action caused by magnesium salts. It seems probable that calcium carbonate sometimes exists in a soluble colloid form, which is changed on boiling to the insoluble modification. The author is still investigating the subject. S. C. H.

TRICHLORACETIC ACID is said to be the best and quickest escharotic yet known for warts, corns and bunions (*Merck's Bull.*, 1, **5**, 1888). S. C. H.

HYDROXYCYANIDE OF MERCURY is likely to take the place of corrosive sublimate. It does not attack the metal of surgical instruments, and in some cases shows six times the bactericidal power of corrosive sublimate (*Merck's Bull.*, 1, **5**, 1888). S. C. H.

ON TWO NEW CHLORIDES OF INDIUM, AND ON THE VAPOR DENSITY OF THE CHLORIDES OF INDIUM, GALLIUM, IRON AND CHROMIUM. L. F. Nilson and Otto Petterson (*Ann. Chim. Phys.*, **6**, xv, 545).—The only chloride of indium heretofore known is obtained by heating the metal in an excess of chlorine. According to C. and V. Meyer's determinations of its vapor density, it has the formula $InCl_3$. The experiments of the authors confirm this. By heating indium in a current of dry hydrochloric acid gas a chloride, $InCl_2$, is formed, which, though very stable at high temperatures and when kept dry, is imme-

diately decomposed by water, thus, $3InCl_2 = 2InCl_3 + In$. The dichloride, when heated with an excess of In, forms a monochloride InCl, a red substance resembling hematite. This, like $InCl_2$ is decomposed by water, $3InCl = InCl_3 + In_2$. The correctness of the formulæ of both the new chlorides is amply established by their vapor densities. Experiments were also made to ascertain the true formulæ of the chlorides of gallium and chromium, which lead to the acceptance of $GaCl_2$, $GaCl_3$, $CrCl_2$, $CrCl_3$. The so-called sesquichlorides of gallium and chromium must, therefore, in future be expressed by the simpler formulæ, $GaCl_3$,$CrCl_3$. The formula of ferrous chloride, $FeCl_2$, was confirmed.

S. C. H.

RESEARCHES ON COBALT AND NICKEL. Gerhard Krüss and F. W. Schmidt (*Ber.*, **22**, 11).—The authors were engaged in re-determining the atomic weights of nickel and cobalt, by Winkler's method. A weighed quantity of the metal was immersed in a solution of chloride of gold, and the amount of the gold thus expelled determined. In spite of many experiments the results obtained did not agree with the values, as determined by Zimmermann or Winkler, and it was found on closer examination that the precipitated gold contained a small quantity of cobalt (or nickel). In order that this might be removed the precipitate was dissolved in aqua regia, and after the excess of acid had been expelled, the gold was re-precipitated by sulphurous acid. The difference in weight of the gold before and after purification was deducted from the weight of the cobalt (nickel or) taken. Even with this precaution the results obtained were not constant.

On washing gold which had been first precipitated by cobalt, and subsequently by sulphurous acid, it was observed that the last washings were somewhat green. This portion of the filtrate was evaporated to dryness; the residue, after ignition, dissolved on heating in concentrated hydrochloric acid, giving rise to a beautiful green solution, which became almost colorless on cooling. With nickel, the same was observed. The reaction, clearly, was not that of any known substance, and, as in both cases, the amount obtained was extremely small, experiments were started in the hope of extracting larger quantities. This has been successfully accomplished by the authors in several ways.

(1) By repeatedly treating precipitated sulphide of nickel with ammonic sulphide, the nickel was gradually dissolved and the ultimately insoluble residue was found to contain considerable quantities of the desired body.

(2) By crystallizing solutions containing corrosive sublimate and chloride of nickel (or cobalt), the double chlorides separate and the new substance could be obtained from the mother liquor.

(3) By treating the oxides of cobalt and nickel with fused alkalies, the oxide of the new body alone dissolves. In this way about two per cent. of the pure oxide may be obtained from oxide of nickel.

The new oxide gives the following reactions: Ammonic sulphide causes a black precipitate from neutral solutions; ammonia, a white, voluminous precipitate insoluble in excess. The chloride is white when pure, but in contact

with strong hydrochloric acid is greenish. The chloride, but not the oxide, is reduced to a black metal at a red heat.

The following, having reference to the above, is an extract from a letter written by Dr. Krüss, and published in the *Chemical News* of January 25th:

"I have in fact succeeded in splitting up nickel and cobalt each into two parts, and both these metals have one component in common. In concert with my colleague I sent a brief notice on this subject to the *Berichte*, which will appear in Berlin on Monday next (the above is abstracted from this paper here referred to). The matter communicated in this short memoir has been intentionally kept very scanty, and I gave as little room as possible to speculation for fear of being led to assertions which I might, perhaps, soon have to withdraw. Meantime, I have fully confirmed our first observations, and we have now about ten different methods by which we can resolve these bodies, hitherto regarded as elementary, each into two parts. We shall soon give a full report on our results, but in the meantime I may inform you, as a curious fact, that we have succeeded in obtaining *green* so-called nickel salts from *red* cobalt salts and the *colorless* salts of the substance which accompanies both metals, and farther, in transforming some green nickel salts into red cobalt salts and other components. This may sound alchemical, but it cannot be denied. As for the spectra of the three components of cobalt and nickel, we have not yet, with the ordinary experimental arrangements, observed any characteristic lines. This is doubtless the reason why hitherto no spectral lines have been found common to pure cobalt and nickel."

S. C. H.

BOOK NOTICES.

INORGANIC COAL AND LIMESTONE IN AN ELECTRO-CHEMICAL WORLD. By Titus Salter Emery.

A memoir of this character has seldom had a better title than the above. The electro-chemical world, if not the inorganic coal and limestone, are undoubtedly and exclusively by Titus Salter Emery.

In the preface we find that the writer has had a grievance against Prof. J. P. Lesley in reference to some of the measures pronounced by the latter below the lower productive coal series of Pennsylvania, and while the author of this epoch-making pamphlet pays every possible deference and respect to Professor Lesley's descriptive powers and zeal, he proves that the State Geologist was hopelessly wrong in his condemnation of the Tipton Run coal field. So far all is well, but emboldened by the victory over our official geologist, he drops into cosmogony, and the unhappy sub-carboniferous of Blair County must bear the blame of some of the most remarkable statements in physics, chemistry and geology, and some of the boldest conceptions of the genesis of rocks of this or of any age.

The contents of chapter I inform us that "stone coal is a rock, carbon is a metal, all gases are metallic," and, as if these startling statements were

thought likely by the author to too greatly fatigue the mind, he soothes it by the next dictum, that "limestone is a chemical compound," etc.

We have not space or time to follow the statements of this chapter. The usual "most distinguished geologists, chemists," etc., are invoked on all occasions to father statements that would take a good deal of trouble to establish without them. "Like heat, electricity," we are told, "is latent in all matter." "It is a recognized law of chemistry (*sic*) that all matter may be reduced to the gaseous form." "Electricity governs the rotation of the earth upon its axis." "The molecular weight" * * * "is never less than twice the density of the substance in the form of gas." [*Vide* mercury and cadmium.]

"A study of the rocks of Pennsylvania indicates that they are all of *volcanic* origin." "Our most popular geologists claim that limestone is of animal origin," etc. [See Dr. Hunt's Chemical and Geological Essays.] "The almost universal theory of geologists of the highest repute is, that coal, being of vegetable origin, cannot have grown in the agitated waters of the ocean." (!)

"The most noted of our geologists and botanists assert with great positiveness that the carboniferous age has long since passed *its period of greatest luxuriance.*"

"If we assume that among the escaping gases which agitate the surface of the liquid lava *silicon* predominates," etc.

These quotations are more than enough from the work. The conclusions are summed up in the explanation of seven plates, which, by the concluding assertion of the argument of the Mosaic and the geological history, would seem to represent the seven days of the creation. But that day which was taken as one of rest is represented by a plate which is remarkable for its demand on the imaginative power. There are other plates, oo and o, which probably correspond to pre-creative time. The task of reviewing their descriptions or describing their plates is too great. Suffice it to say that the busy worker is now and then solaced by a book of this kind, which lets his pent up volcanic thoughts loose, and doubtless relieves him. Let no one take it too seriously. F.

DEVELOPMENT OF TRANSPORTATION SYSTEMS IN THE UNITED STATES. Comprising a comprehensive description of the leading features of advancement, from the colonial era to the present time, in water channels, roads, turnpikes, canals, railways, vessels, vehicles, cars and locomotives; the cost of transportation at various periods and places by the different methods; the financial, engineering, mechanical, governmental and popular questions that have arisen; and notable incidents in railway history, construction and operation. With illustrations of hundreds of typical objects—by J. L. Ringwalt, Editor of the *Railway World;* Philadelphia, folio, 1888, 446 pages, price $5.

This large and elaborate work, equal to over 1,000 octavo pages, besides forty-eight folio pages of illustrations, is a veritable compendium of facts and data pertaining to all kinds of transportation in the United States, set forth in clear and lucid style. Only by much ability, industry and effort could such a collection have been made and exhibited; it is also the saving of a large amount of important matter from destruction or oblivion. There are refer-

ences to over 1,500 railroads, in the constant mention and discussion of the numerous subjects connected with them and the other modes of transportation. The relations of these systems one to another, and their influence against, or in favor of one another are well set forth; and the chief features of American railways are shown from their inception to the date of this publication. Extensive and valuable data are given—frequently in tabular form; and the subjects discussed include, among many others, Early canal financiering, Effects of the completion of the Erie Canal, Cost of canal transportation, Passenger traffic, Early railway financiering, Economic results of early railways, Cost of early freight movements, Effect and extent of reductions of cost of overland transportation, etc.

After the discussion of the ancient modes of transportation on the backs of horses and mules, in rude sleds or wagons drawn by animals, or in arks and on rafts in rivers, much information is given respecting early forms of locomotives, tenders and cars, kinds of flat wrought-iron rails, also ties and sills, together with the failure of stone blocks used instead of ties, and the annoyance and accidents occasioned by the curling up into snags of the ends of flat rails. Accounts of improvements in construction of locomotives, cars, and in management of roads, are rendered in a full and conscientious manner, and their further development traced with precision. This requires a multitude of subjects, among which we can mention only a few, as affording a general idea of the extent of this historical examination—viz: Tunnels, bridges and inclined planes, Rivalry between land and water routes, Position of the competing systems, Railway construction 1830 to 1850, First railway-stock panics, Progress in road and bridge building, Railway supplies, Statistics of constructions and operations 1840, 1850, 1855, 1860, 1870, Consolidation of connecting lines, Operations of trunk lines, Fast freight and express passenger lines, Railways to develop coal regions, Improved grading, Substitution of the cast T-rail for the flat, and of steel for iron rails, Modes of signalling, etc.

While such development is shown in railroads in the earlier and middle period up to 1870, that of the steamboat, at the same time, is as faithfully portrayed. The first forms of the rude attempts at steam navigation are described and illustrated, and there follow the progress in this art from 1840 to 1850, their further improvement up to 1860 and 1870, including the development of passenger and freight steamers for river, lake and coast-wise service, tugboats, steam dredges and the grand trans-Atlantic steamers. In this middle stage, as it might be called, there is some account given of the origin and application of the screw propeller—not, however, as full as desirable; and the author does not say as much as we thought he would have said, respecting the Baltimore and Philadelphia Steamboat Company ("Ericsson Line"), via the Chesapeake and Delaware Canal, which line (chartered by Maryland, February 23, 1844, and still daily continued) was the first to carry passengers and freight between American cities in vessels having screw propellers. The use of such mode in tugboats commenced five years earlier. This was most important, as developing into the present mode of propulsion of trans-Atlantic steamers. On the latter point there is a considerable amount of information given in this work.

In the period from 1870 to date of publication, denominated "Railway Manhood"—equally so of steam navigation—the historical items and data are very numerous, including much respecting civil and mechanical engineering and mechanical improvements on railways, locomotives, cars and steamers. Prominent notice is given of bridge construction over principal rivers, including wire-suspension bridges, and various descriptions of trusses, with some notable new forms; also the building of tunnels and culverts, railway machine-shops, stations, dépôts and tanks and automatic scoop-troughs for water supply of tenders. Much attention is given in this division to Terminal railway shipping facilities for coal, oil and general merchandise, Increase of varieties of locomotives and cars, Increase of size and power of locomotives and their adaptation to anthracite and slack anthracite coal, Improvement in details of locomotives and general improvements, Capacity of freight cars, Steam brakes and other improvements in car-trucks, wheels and axles, Modes of heating cars, Switches and signals, plain and automatic, and the "block system" along with telegraphic installation for the same, Telegraph communication between stations and between cars in motion, Electric illumination of roads, stations and cars, Iron coal-cars, Grain elevators, Cattle and refrigerating cars, Extensive wharves and facilities for storing and handling coal, Increased mileage of railways, Increase in length of trains and increase in speed of passenger and express trains, Various systems of management, Personnel and legal, traffic and operating departments, Railway relief and insurance associations, etc.

In this and the previous period the rise and progress is noted of the most important pioneer locomotive works such as the Baldwin Locomotive Works, Philadelphia, the Rogers, of Paterson, and others, with honorable mention of the Norris Locomotive Works, of Philadelphia, an establishment now passed away, but useful and eminent in its day. During these two periods the Pennsylvania Railroad Company is well sketched, from its commencement of work in 1849 (sixty-one miles that year) with 102 index references, the New York, Lake Erie and Western with sixty-four, Baltimore and Ohio sixty-seven, Philadelphia and Reading fifty, and several other main roads with twenty to forty-five index references.

In the latter period, though there is less attention given to the development of steamers, there is much respecting the gradual increase in size of vessels and the power of their engines, with more use of high-pressure steam. The vast size and increasing elegance of some passenger steamboats—like those plying on Long Island Sound—is noted, and the gradual improvement of the screw propeller and the wonderful rise of the vast trans-Atlantic lines of steamers, with application of the mixed condensing and high-pressure steam engines, and a constant tendency to increase of size and speed in these vessels.

We are aware that the above is a rather meagre citation from the immense number of subjects included in this really elaborate volume. The more we have examined it, the more we admire the industry, energy and good judgment of the author. As a work intended to assist the future historian too much praise cannot be given; but it also directly interests a

large class of business men, such as merchants, bankers, journalists, lawyers, legislators, railway directors and operators, civil and mechanical engineers, students of economic science, etc. All these will find much of interest in this history, and, possibly, what may prove of great value in legal questions.

The illustrations form a valuable portion of this work. Of them there are forty-eight pages, a few containing two, but the most six to twelve designs, showing graphically the first rude wagons, arks, canal boats, steamboats, locomotives, cars, bridges and trestle work. Next are exhibited similar but vastly improved forms, including the T cast-iron rail, of several descriptions, and finally magnificent locomotives and palace cars of the present day, immense river steamboats and Atlantic steamers, powerful tug and ice boats, improved forms of light-houses, etc. A number of maps show the railroad system of the United States. A full index of railways and a general index close the volume. In glancing over these their value will be appreciated, and it will be seen that the above citations of subjects have been comparatively small in number. We cordially recommend this excellent compendium of transportation history and literature, and wish for it the wide circulation in the United States, Canada and Europe which it so well deserves. One thing is certain, it is destined to become a standard work of reference. N.

MICROSCOPICAL PHYSIOGRAPHY OF THE ROCK-MAKING MINERALS AND AN AID TO THE MICROSCOPICAL STUDY OF ROCKS. By H. Rosenbusch. Translated and arranged for use in schools and colleges, by Joseph P. Iddings. Illustrated by 121 wood-cuts and twenty-six plates of photo-micrographs. New York: John Wiley & Sons, 15 Astor Place.

This is a very important and much needed work. It places the student who cannot read German, for the first time in several years in a position abreast of the times; for to prosecute micro-mineralogy without Rosenbusch is like studying law without Blackstone, or (a better simile would be) without the record of modern cases. The work is a great improvement on Rosenbusch's first edition of 1873, and, for the practical student, even of that of 1885. The English is an abridgment of the German work, yet the portions cut out are not such as to mar in any way the usefulness of the book to the English or American student.

As stated by the translator in his preface, the omissions are chiefly of the historical matter, and of the thorough discussion of the optical anomalies of certain minerals. The nomenclature and the method of Prof. Rosenbusch are preserved, except in the first named three or four words, for which there was good reason to retain the forms generally current in American petrological literature.

In the first or general part of the book, after a few words on the preparation of the material for examination, which might, with advantage, have been extended, the main subjects rendered familiar by Rosenbusch's treatment are taken up, and in clear and scientific English are laid before the reader.

The print and paper are excellent (as is usual with Wiley's scientific publications), and the twenty-six plates of micro-photographed figures are

admirably chosen for illustration, and generally good as specimens of printing. F.

THE "LAKE SUPERIOR COPPER PROPERTIES," ETC. By Henry M. Pinkham.

This is a handy little pamphlet of 102 pages, which gives a great deal of valuable information concerning the copper properties of the Lake Superior district, but arranged statistically and following a natural order, without invoking the nebular hypothesis and the prophetic imagination. It is accompanied by a skeleton sketch map, on which the approximate positions of the chief copper mines are set down. It treats of the districts in the order in which they were known as copper districts by the public, viz: Keweenaw, Ontonagon and Houghton.

The concluding three pages are devoted to excerpts from the report of President Clark and Treasurer Bigelow in the last annual report of the Tamarack Mining Company, taking strong ground in favor of the course of controlling all the great mines of the world, to secure their "well being," because "the stimulus of present prices will necessarily lead all parties to crowd to their utmost all their energies in the line of production, and if this output is thrown upon the market without control, it will surely result in disaster, while under the present ownership and management it will not be difficult to compel an equitable distribution."

It is a necessity to all those who are interested either in mines in Michigan or in copper. F.

BULLETIN NO. 5, OF THE STATE COLLEGE AGRICULTURAL EXPERIMENT STATION. October, 1888.

This little pamphlet of eleven pages, by William Frear, Vice-Director and Chemist, is devoted to a treatise of the digestibility of soiling rye, giving the plan of experimentation and comparison with other fodders. The coefficients of digestibility of the material fed to two steers form the concluding lines of an interesting table, and will surprise the non-professional agricultural chemist by the closeness of agreement of the results of these processes in Nature's laboratories—the animal stomachs.

The whole paper is interesting and illustrates the importance of liberally endowing these scientific establishments of the state. F.

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[*Proceedings of the Annual Meeting, held Wednesday, February 20, 1889.*]

HALL OF THE INSTITUTE,
PHILADELPHIA, February 20, 1889.

JOSEPH M. WILSON, President, in the Chair.

Present, 119 members and nine visitors.

Additions to membership since last report, seventy-nine.

The Chairman of the Special Committee to Increase Membership made a report of progress.

Mr. F. LYNWOOD GARRISON exhibited a series of handsome specimens of artistic metal work made in Russia, and made some explanatory remarks respecting the same, and on the state of artistic metal working in Russia.

DR. E. S. MCCLELLAN, of Paterson, N. J., presented a communication descriptive of a method and apparatus for automatically preventing the unsealing of house drainage traps by siphoning. A working model was shown, exhibiting the construction and operation of the invention.

The report of the Secretary contained reference to the forthcoming International Exhibition in Paris, and a comparative description of the Electric Reduction Processes of Messrs. Cowles and M. Herault.

Adjourned, WM. H. WAHL, *Secretary.*